Weapons of Mass Destruction

Volume I:
Chemical and
Biological Weapons

Weapons of Mass Destruction

An Encyclopedia of Worldwide Policy, Technology, and History

Eric A. Croddy and James J. Wirtz, Editors

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Foreword by David Kay

Volume I: Chemical and Biological Weapons

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Foreword

David Kay

Senior Research Analyst, Potomac Institute, Washington, D.C., and former Director, Iraq Survey Group (2003–2004)

The importance of this encyclopedia was underscored by the fact that virtually the only area of agreement in the 2004 U.S. presidential campaign between the two major candidates, President George W. Bush and Senator John F. Kerry, was that the proliferation of weapons of mass destruction poses the most serious national security threat with which the next president would have to deal.

While the prospect of chemical, biological, radiological, or nuclear weapons falling into the hands of terrorists or regimes hostile to the United States and its friends is indeed a frightening prospect, how many of us understand exactly what this means? When were such weapons first developed? Which states and scientists are leading these developments? Have these weapons actually been used in the past? How often and with what consequence—not only for the populations they were used against, but for those that used them, as well? Do these weapons really give states a decisive edge over their adversaries? How easy are they to develop and use? Does the ease of development or use of such weapons by states, like North Korea, differ from the obstacles faced by terrorist groups, like al-Qaeda? What are the tools available to the United States to halt the spread of such weapons? Have we had any success in limiting the spread of these weapons? Are there any protective measures that individuals can take to lessen their vulnerability if such weapons are used?

These are but a few of the questions that the authors of this authoritative two-volume study attempt to answer. This encyclopedia will have enduring importance as states and societies attempt to come to terms with the consequence of the collision of scientific progress with the failure to develop a reliable global security structure. The initial development of chemical, biological, and nuclear weapons, as this study makes clear, often involved scientific and engineering breakthroughs of the highest order. The paths to enriching uranium and genetically modifying pathogens are but two examples of such successes, scientific breakthroughs that have made new classes of weapons possible. But scientific progress marches at a very fast rate, leaving behind old, but still dangerous, knowledge. For example, the secrets regarding methods for enriching uranium were simply bought by the Iraqis from the U.S. Government Printing Office. That office could not imagine that there was anything important in a 40-year-old project from the dawn of the U.S. nuclear program.

In another remarkable case, uranium enrichment technology was stolen from a commercial company in Holland by A. Q. Khan—a rather ordinary Pakistani who went to Germany to earn an engineering degree. Khan subsequently used this technology to develop Pakistan's nuclear weapons and then sold the same technology to North Korea, Iran, and Libya. The techniques of gene modification, which less than 20 years ago were the stuff of Nobel prizes, are now routinely taught in American high schools and community colleges and have opened up whole new classes of biological weapons. As this study also makes clear, even the safe disposal of weapons of mass destruction following a state's decision to abandon or limit their programs presents serious challenges of preventing the weapons and associated technology from falling into the hands of terrorists. The thousands of Soviet-era nuclear weapons and the engineering talent that created them represent a clear and present danger with which the world has not yet completely dealt. The readers of this work will find numerous examples of the lowering of the barriers to the acquisition by states and terrorists of these most terrible of weapons.

But this study does not simply present the horrors of a world filled with weapons of mass destruction. It also catalogs and illuminates the various methods of attempting to control and constrain these weapons—including treaties and agreements such as the Nuclear Non-Proliferation Treaty and the Chemical Weapons Convention, as well as intrusive inspections, such as the efforts of the United Nations to hunt such weapons in Iraq after the first Gulf War. As will be clear to the reader, such endeavors have had both successes and failures. Much remains to be done to ensure that their effectiveness matches the problems posed by the proliferation of such weapons. The largest gap in effective mechanisms of control and response to the acquisition of such weapons is with regard to the efforts of terrorists groups to acquire the means of mass murder. While these volumes identify the few efforts made in this regard, it is hard not to come away with a sense of dread for the future. Most control efforts have been aimed at states, not at terrorists operating outside of the control of states. Hopefully students and policy makers using this book a few years hence will be able to record more progress toward meeting this new challenge.

The authors and editors have done an important service by pulling together such an illuminating study at exactly the point when there is a broad political consensus of the importance of the problem. One can only hope that our citizens and our political leaders take the time to explore the depth of information presented here.

Preface: Weapons of Mass Destruction

Eric A. Croddy and James J. Wirtz

The term "weapon of mass destruction" (WMD) is a relatively modern expression. It was probably first used in print media following the international uproar over Germany's aerial bombardment of the Basque city of Guernica in April 1937. (The latter event was famously depicted in Picasso's painting *Guernica y Luno.*) Only a year before, another Axis power, Italy, had begun using mustard and other chemical warfare (CW) agents in Abyssinia (modern-day Ethiopia).[1] During the anxious years leading up World War II, WMD referred to the indiscriminate killing of civilians by modern weaponry, especially aircraft. It also echoed the fear of chemical weapons that was unleashed by World War I, which had come to a conclusion just a few years earlier.

Following the development of the atomic bomb in 1945, the term "WMD" came to include nuclear and eventually biological weapons. WMD was apparently first used to describe nuclear warfare by Soviet strategists. In 1956, during the 20th Communist Party Congress in Moscow, the Soviet Minister of Defense—and "Hero of Stalingrad"—Marshal Georgy Konstantinovich Zhukov prophesied that modern warfare "will be characterized by the massive use of air forces, various rocket weapons and various means of mass destruction such as atomic, thermonuclear, chemical and bacteriological weapons."[2] In that same year, the Hungarian Minister of Defense echoed Marshal Zhukov, stating that "Under modern conditions, the decisive aspect of operational planning is the use of nuclear and other weapons of mass destruction."[3]

When the West learned of Zhukov's speech, national security strategists in the United States and elsewhere became quite concerned. By inference, they concluded that WMD—nuclear, biological, and chemical weapons—were an integral part of Soviet military doctrine. Partly in response to Zhukov's ministrations on WMD, the United States reviewed its offensive chemical and biological weapons program in 1958. The U.S. military was never particularly enamored by chemical or biological weapons and treated them as a deterrent to be used in retaliation for the use of chemical or biological weapons used by the opponent. By the early 1990s, the U.S. military had abandoned offensive use of these weapons, although it maintained a research and development program designed to produce effective equipment, procedures, medications, and inoculations to defend against chemical and biological attack.

Over the last decade, much has been written about WMD. The meaning of the term itself is somewhat controversial, although there is a formal, legalistic definition. According to U.S. Code Title 50, "War and National Defense," per the U.S. Congress, the term "weapon of mass destruction" means "any weapon or device that is intended, or has the capability, to cause death or serious bodily injury to a significant number of people through the release, dissemination, or impact of toxic or poisonous chemicals or their precursors; a disease organism; radiation or radioactivity."[4] For its part, the U.S. Department of Defense has a similar characterization of WMD, although in addition it includes "...the means to deliver [WMD]."[5] So, what makes a weapon massively destructive? Is it the type of injurious agents involved, namely radioactive, chemical, or biological, or is it that the attack itself produces significant casualties or destruction? Also what would "significant" mean in this context: ten, a hundred, or a thousand casualties? What if very few people are actually killed or hurt by at attack? In the latter respect, the U.S. Federal Bureau of Investigation has a rather unique and somewhat satisfying interpretation of the term "WMD," invoked when the U.S. government indicted Timothy McVeigh with using a WMD in his 1995 terrorist attack in Oklahoma City. In this case, although the device used was a conventional bomb (employing ammonium nitrate-fuel oil explosive), "A weapon crosses the WMD threshold when the consequences of its release overwhelm local responders."[6]

Some analysts, however, have suggested that various technical hurdles prevent chemical and even biological weapons from causing casualties on a truly massive scale. Some point to the Aum Shinrikyo sarin attack on the Tokyo subway system on March 20, 1995, which resulted in eleven deaths, as an example of the *limits* of WMD. They note that high-explosives have been used with far greater lethal effects than sarin in the annals of modern terrorism. Others are increasingly concerned about the destructive potential of even rudimentary weapons. Analysts today are worried, for instance, that terrorists might try to employ radiological dispersal devices or "dirty bombs." These weapons do not detonate with a fission reaction, but rather utilize conventional explosives to distribute radiological materials and contaminate a given area. Few deaths are likely to result from the effects of a dirty bomb, but the consequences—in terms of anxiety, clean-up, and the recognized ability of a terrorist to conduct the very act itself—would likely be far reaching.

About the Encyclopedia

The very presence of chemical, biological and nuclear weapons in international arsenals and the potential that they might fall into the hands of terrorist organizations guarantees that weapons of mass destruction will be of great policy, public, and scholarly interest for years to come. We cannot resolve the debates prompted by WMD, but we hope that we and our contributors can provide facts to help the reader sort through the controversies that are likely to emerge in the years ahead. Much that is contained in these volumes is disturbing and even frightening; it is impossible to write a cheery encyclopedia about weapons whose primary purpose is to conduct postindustrial-scale mass murder. The sad truth of the matter is that chemical, biological, radiological, and nuclear weapons reflect the willingness of humans to go to great lengths to find increasingly lethal and destructive instruments of war and violence. We are pleased to note, however, that much of what is reported in these volumes is historical in nature and that civilized people everywhere reject the use of chemical and biological weapons. International law is replete with treaties, agreements, and regimes whose purpose is to proscribe the use of these weapons, or mitigate the consequences of any such use. In particular, the world has successfully kept nuclear weapons in reserve for almost sixty years as truly deterrent weapons of last resort.

Our encyclopedia covers a wide range of topics, some historical, some drawn from today's headlines. We describe many of the pathogens, diseases, substances, and machines that can serve as weapons of mass destruction, as well as their associated delivery systems. We also describe important events and individuals that have been influential in the development of weapons of mass destruction and doctrines for their use (or control). We have encouraged our contributors to highlight ongoing controversies and contemporary concerns about WMD and current international arms control and nonproliferation efforts intended to reduce the threat they pose to world peace and security. Even a work of this length, however, cannot completely cover the history, science, and personal stories associated with a topic of this magnitude, so we have included abundant references to help readers take those initial steps for further study of the topics we survey.

Acknowledgments

Our deepest debt is to the contributors who made this volume a reality. Many of them joined the project at its inauguration several years ago and have waited a long time to see their work in print. It is impossible for just three people to be experts on all of the subjects covered in this volume, and without the hard work of our contributors, this encyclopedia would never have been completed. Thanks to our research assistants, Abraham Denmark and Laura Fontaine, who uncovered most of the key documents in both volumes and wrote a few entries for us, as well. We also want to express our appreciation to a senior government official who reviewed Volume II for accuracy and sensitive material. We owe a special debt to Jeff Larsen, our managing editor, whose help was instrumental in the success of this project. Not only did he provide editorial support to both volumes, but he displayed a keen ability to deal with the publisher and our 95 contributors, keep track of timelines, requirements, and progress, and gently push the two of us when we needed encour-

agement during this multiyear project that involved over 500 separate parts. Finally, we also want to express our appreciation to Alicia Merritt, Martha Whitt, Giulia Rossi, and the behind-the-scenes copyeditors at ABC-CLIO who worked tirelessly to help get this manuscript into print. We discovered that nothing is a trivial matter when it comes to a manuscript of this size. The commitment of our publisher to this topic, and the dedication of the production staff at ABC-CLIO, greatly facilitated the completion of these volumes.

We hope that this encyclopedia will help inform the public debate about weapons of mass destruction and international security policy, with the goal of never again seeing such weapons used in anger.

Notes

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2. Jeffery K. Smart, "History of Chemical and Biological Warfare: An American Perspective," in Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz, eds., *Textbook of Military Medicine, Part I: Warfare, Weaponry, and the Casualty: Medical Aspects of Chemical and Biological Warfare* (Washington, DC: Borden Institute, Walter Reed Army Medical Center, 1997), p. 54.
3. Quoted in the archives, "Report of Colonel-General István Bata, Hungarian Minister of Defense, to Members of the HWP Central Committee on the Conduct of the Staff-Command Exercise Held, 17 July 1956," found at the International Relations and Security Network (Switzerland), documents collection, *http://www.isn.ethz.ch/*
4. Title 50, Chapter 40, Sec. 2302.
5. Office of the Secretary of Defense, *Proliferation: Threat and Response* (Washington, DC: U.S. Government Printing Office, 2001), p. 4.
6. U.S. Federal Bureau of Investigation (FBI), "The FBI and Weapons of Mass Destruction," 4 August 1999, *http://norfolk.fbi.gov.wmd.htm*

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A to Z List of Entries, Volumes I and II

Volume I: Chemical and Biological Weapons

Aberdeen Proving Ground
Abrin
Adamsite (DM, diphenylaminochlorarsine
Aerosol
Agent Orange
Agroterrorism (Agricultural Biological Warfare)
Al-Qaeda
Al Shifa
Amiton (VG)
Ammonium Nitrate Fuel Oil (ANFO)
Anthrax
Aralsk Smallpox Outbreak
Arbusov Reaction
Arsenicals
Atropine
Aum Shinrikyo
The Australia Group

Bari Incident
Bhopal, India: Union Carbide Accident
Bigeye (BLU-80)
Binary Chemical Munitions
Biological and Toxin Weapons Convention (BTWC)
Biological Terrorism: Early Warning via the Internet
Biological Warfare
Biopreparat
Bioregulators
Bioterrorism
Bleach
Blood Agents
Botulism (Botulinum Toxin)
Brucellosis (Brucella Bacterium)

C-4
Carbamates
Centers for Disease Control and Prevention (CDC)
Chemical Agent Monitor
Chemical and Biological Munitions and Military Operations
Chemical Warfare
Chemical Weapons Convention (CWC)
Chlamydia Psittaci (Psittacosis)
Chlorine Gas
Chloropicrin (PS, Trichloronitromethane)
Choking Agents (Asphyxiants)
Cholera (Vibrio cholerae)
Conotoxin
Crimean-Congo Hemorrhagic Fever
Crop Dusters (Aerial Applicators)
CS
Cyclosarin (GF)

Decontamination
Demilitarization of Chemical and Biological Agents
Dianisidine
Difluor (DF, Difluoromethylphosphonate)
Diisopropyl Fluorophosphate (DFP)
Dioxin
Diphosgene
Dual-Use
Dugway Proving Ground

EA2192
EMPTA (O-Ethyl Methylphosphonothioic Acid)
Enterovirus 70
Equine Encephalitis (VEE, WEE, EEE)
Ethiopia (Abyssinia)
Explosives

Fentanyl
Fermenter
Foot-and-Mouth Disease Virus

Fort Detrick
Fuel-Air Explosive (FAE)

Gas Gangrene
Geneva Protocol
Glanders (Burkholderia Mallei)
Gruinard Island
G-Series Nerve Agents
Gulf War: Chemical and Biological Weapons
Gulf War Syndrome

Hague Convention
Halabja Incident
Heartwater (Cowdria Ruminantium)
Hemorrhagic Fevers
Herbicides

India: Chemical and Biological Weapons Programs
Inversion
Iran: Chemical and Biological Weapons Programs
Iran-Iraq War
Iraq: Chemical and Biological Weapons Programs

Japan and WMD
Johnston Atoll

Kaffa, Siege of
Korean War

Late Blight of Potato Fungus (Phytophthora Infestans)
Libya and WMD
Line Source
Livens Projector
Lyophilization

Marburg Virus
Melioidosis
Microencapsulation
Mustard (Sulfur and Nitrogen)
Mycotoxins

Napalm
Nerve Agents
Newcastle Disease
Newport Facility, Indiana
North Korea: Chemical and Biological Weapons Programs
Novichok

Oklahoma City Bombing
Organophosphates
Osama bin Laden
Oximes

Parasites—Fungal
Parathion (Methyl and Ethyl)
Perfluoroisobutylene (PFIB)
Phosgene Gas (Carbonyl Chloride)
Phosgene Oxime (CX, Dichloroform Oxime)
Pine Bluff, Arkansas
Plague
Plasticized Explosives
Point Source
Porton Down, United Kingdom
Precursors
Protective Measures: Biological Weapons
Protective Measures: Chemical Weapons
Psychoincapacitants
Pyridostigmine Bromide

Q-Fever
QL

Ricin
Rift Valley Fever
Riot Control Agents
Rocky Mountain Spotted Fever
Russia: Chemical and Biological Weapons Programs

Sabotage
Salmonella
Sarin
Semtex
Shikhany
Simulants
Sino-Japanese War
Skatole
Smallpox
Soman
South Africa: Chemical and Biological Weapons Programs
South Korea: Chemical and Biological Weapons Programs
Spore
Stabilizers
Staphylococcal Enterotoxin B
Stepnogorsk
Sverdlovsk Anthrax Accident

Syria: Chemical and Biological Weapons Programs

Tabun
Terrorism with CBRN Weapons
Thickeners
TNT
Tobacco Mosaic Virus
Tooele, Utah
Toxins (Natural)
Toxoids and Antitoxins
Tularemia
Tuberculosis (TB, Mycobacterium Tuberculosis)
Typhus (Rickettsia Prowazekii)

Unit 731
United Kingdom: Chemical and Biological Weapons Programs
United Nations Monitoring, Verification, and Inspection Commission (UNMOVIC)
United Nations Special Commission on Iraq (UNSCOM)
United States: Chemical and Biological Weapons Programs
Unmanned Aerial Vehicle (UAV)

Vaccines
V-Agents
Vector
VECTOR: State Research Center of Virology and Biotechnology
Vesicants
Vietnam War
Vincennite (Hydrogen Cyanide)

Weteye Bomb
World Trade Center Attack (1993)
World War I
World War II: Biological Weapons
World War II: Chemical Weapons
Wushe Incident

Xylyl Bromide

Yellow Rain
Yemen
Ypres

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Accidental Nuclear War
Accuracy
Acheson-Lililenthal Report
Actinides
Airborne Alert
Anti-Ballistic Missile (ABM) Treaty
Antinuclear Movement
Anti-Satellite (ASAT) Weapons
Arms Control
Arms Control and Disarmament Agency (ACDA)
Arms Race
Assured Destruction
Atomic Energy Act
Atomic Energy Commission
Atomic Mass/Number/Weight
Atoms for Peace

Backpack Nuclear Weapons
Balance of Terror
Ballistic Missile Defense Organization (BMDO)
Ballistic Missile Early Warning System (BMEWS)
Ballistic Missiles
Baruch Plan
Bikini Island
Bombers, Russian and Chinese Nuclear-Capable
Bombers, U.S. Nuclear-Capable
Boost-Phase Intercept
Bottom-Up Review
Brilliant Eyes
Brinkmanship
British Nuclear Forces and Doctrine
Broken Arrow, Bent Spear

Canada Deuterium Uranium (CANDU) Reactor
The Catholic Church and Nuclear War
Chelyabinsk-40
Chernobyl
Cheyenne Mountain, Colorado
Chicken, Game of
Chinese Nuclear Forces and Doctrine
City Avoidance
Civil Defense
Cold Launch
Cold War
Collateral Damage
Command and Control
Committee on the Present Danger
Compellence
Comprehensive Test Ban Treaty (CTBT)
Conference on Disarmament
Conference on Security and Cooperation in Europe (CSCE)

Confidence- and Security-Building Measures (CSBMs)
Containment
Cooperative Threat Reduction (The Nunn-Lugar Program)
Coordinating Committee for Multilateral Export Controls (COCOM)
Correlation of Forces
Counterforce Targeting
Countermeasures
Counterproliferation
Countervailing Strategy
Countervalue Targeting
Coupling
Credibility
Crisis Stability
Critical Nuclear Weapons Design Information (CNWDI)
Criticality and Critical Mass
Cruise Missiles
Cuban Missile Crisis

Damage Limitation
Data Exchanges
The Day After
Dealerting
Decapitation
Declared Facility
Decoys
Defense Threat Reduction Agency (DTRA)
Dense Pack
Department of Defense (DOD)
Department of Energy (DOE)
Department of Homeland Security (DHS)
Depleted Uranium (U-238)
Deployment
Depressed Trajectory
Détente
Deterrence
Deuterium
Disarmament
Distant Early Warning (DEW) Line
Downloading
Dual-Track Decision

Early Warning
Emergency Action Message (EAM)
Enola Gay
Enrichment
Entry into Force
Equivalent Megaton
Escalation
Essential Equivalence
European Atomic Energy Community (EURATOM)
Extended Deterrence

Failsafe
Fallout
Fast Breeder Reactors
Fat Man
Federal Emergency Management Agency (FEMA)
Federation of American Scientists (FAS)
Firebreaks
First Strike
Fissile Material Cutoff Treaty (FMCT)
Fission Weapons
Flexible Response
The Football
Forward-Based Systems
Fractional Orbital Bombardment System (FOBS)
Fratricide
French Nuclear Forces and Doctrine
Fuel Fabrication
Fusion

G8 Global Partnership Program
Gaither Commission Report
Game Theory
Gas-Graphite Reactors
Geiger Counter
Global Protection Against Limited Strikes (GPALS)
Graphite
Gravity Bombs
Ground-Launched Cruise Missiles (GLCMs)
Ground Zero
Gun-Type Devices

Half-Life
Hanford, Washington
Hard and Deeply Buried Targets
Harmel Report
Heavy Bombers
Heavy ICBMs
Heavy Water
Hedge
Highly Enriched Uranium (HEU)
Hiroshima
Horizontal Escalation
Hot Line Agreements

Hydrogen Bomb

Implementation
Implosion Devices
Improvised Nuclear Devices
Inadvertent Escalation
Indian Nuclear Weapons Program
Inertial Navigation and Missile Guidance
Institute for Advanced Study
Intercontinental Ballistic Missiles (ICBMs)
Intermediate-Range Nuclear Forces (INF) Treaty
International Atomic Energy Agency (IAEA)
Iranian Nuclear Weapons Program
Iraqi Nuclear Forces and Doctrine
Isotopes
Israeli Nuclear Weapons Capabilities and Doctrine

Joint Chiefs of Staff (JCS)
Joint Declaration on Denuclearization of the Korean Peninsula

Kiloton
Kwajalein Atoll

Launch on Warning/Launch under Attack
Launchers
Lawrence Livermore National Laboratory
Light-Water Reactors
Limited Nuclear War
Limited Test Ban Treaty (LTBT)
Lithium
Little Boy
Long-Range Theater Nuclear Forces
Los Alamos National Laboratory
Low Enriched Uranium (LEU)

Maneuvering Reentry Vehicle (MARV)
Manhattan Project
Massive Retaliation
Medium-Range Ballistic Missiles
Megaton
Megawatt
Midgetman ICBMs
Military Technical Revolution (Revolution in Military Affairs)
Minimum Deterrence
Ministry of Atomic Energy (MINATOM)
Minuteman ICBM
Missile Defense
Missile Gap
Missile Technology Control Regime (MTCR)
Mixed Oxide Fuel (MOX)
Mobile ICBMs
Moratorium
Moscow Antiballistic Missile System
Multilateral Nuclear Force
Multiple Independently Targetable Reentry Vehicle (MIRV)
Multiple Launch Rocket System (MLRS)
Mutual Assured Destruction (MAD)

Nagasaki
National Command Authority
National Emergency Airborne Command Post (NEACP)
National Strategic Target List
National Technical Means
Negative Security Assurances (NSAs)
Neutron Bomb (Enhanced Radiation Weapon)
Neutrons
Nevada Test Site
New Look
Nike Zeus
No First Use
Non–Nuclear Weapons States
Nonproliferation
North American Aerospace Defense Command (NORAD)
North Atlantic Treaty Organization (NATO)
North Korean Nuclear Weapons Program
Nuclear Binding Energy
Nuclear Emergency Search Teams (NESTs)
Nuclear Fuel Cycle
Nuclear Nonproliferation Treaty (NPT)
Nuclear Planning Group
Nuclear Posture Review
Nuclear Regulatory Commission (NRC)
Nuclear Risk Reduction Centers (NRRCs)
Nuclear Suppliers Group
Nuclear Taboo
Nuclear Test Ban
Nuclear Warhead Storage and Transportation Security (Russia)
Nuclear Weapons Effects
Nuclear Weapons Free Zones (NWFZs)
Nuclear Weapons States
Nuclear Winter

Oak Ridge National Laboratory
On the Beach

One-Point Detonation/One-Point Safe
On-Site Inspection Agency (OSIA)
Open Skies Treaty
Outer Space Treaty
Overhead Surveillance

Pakistani Nuclear Weapons Program
Pantex Facility, Texas
Parity
Payload
Peaceful Coexistence
Peaceful Nuclear Explosions
Peaceful Nuclear Explosions Treaty (PNET)
Peacekeeper Missile
Penetration Aids
Permissive Action Link (PAL)
Pershing II
Phased-Array Antenna
Pit
Plutonium
Polaris SLBMs/SSBNs
Portsmouth Enrichment Facility
Poseidon SLBMs/SSBNs
Post-Attack Command and Control System (PACCS)
Preemptive Attack
Presidential Nuclear Initiatives
Pressurized-Water Reactors (PWRs)
Preventive War
Primary Stage
Proliferation
Proliferation Security Initiative
Pugwash Conferences

Quadrennial Defense Review

Radiation
Radiation Absorbed Dose (Rad)
Radiological Dispersal Device
The RAND Corporation
Rapacki Plan
Ratification
Reactor Operations
Reasonable Sufficiency
Reciprocal Fear of Surprise Attack
Reconnaissance Satellites
Red Mercury
Reentry Vehicles
Reliability
Reprocessing
Research Reactors
Restricted Data (RD)
Reykjavik Summit
Ride Out
Rocky Flats, Colorado
Roentgen Equivalent Man (Rem)
Rumsfeld Commission
Russian Nuclear Forces and Doctrine

Safeguard Antiballistic Missile (ABM) System
Safeguards
Sandia National Laboratories
Savannah River Site, South Carolina
Sea-Launched Cruise Missiles (SLCMs)
Second Strike
Selective Options
Sentinel Antiballistic Missile System
Short-Range Attack Missiles (SRAM)
Shrouding
Silo Basing
Single Integrated Operational Plan (SIOP)
Skybolt
South African Nuclear Weapons Program
South Korean Nuclear Weapons Program
Space-Based Infrared Radar System (SBIRS)
Spartan Missile
Sprint Missile
Sputnik
Standing Consultative Commission (SCC)
Stealth Bomber (B-2 Spirit)
Stockpile Stewardship Program
Strategic Air Command (SAC) and Strategic Command (STRATCOM)
Strategic Arms Limitation Talks (SALT I and SALT II)
Strategic Arms Reduction Treaty (START I)
Strategic Arms Reduction Treaty (START II)
Strategic Defense Initiative (SDI)
Strategic Defenses
Strategic Forces
Strategic Offensive Reductions Treaty (SORT)
Strategic Rocket Forces
Submarines, Nuclear-Powered Ballistic Missile (SSBNs)
Submarine-Launched Ballistic Missiles (SLBMs)
Sufficiency
Superiority
Surety
Surprise Attack Conference
Surveillance

Survivability

Tactical Nuclear Weapons
Telemetry
Terminal Phase
Theater High Altitude Air Defense (THAAD)
Theater Missile Defense
Thermonuclear Bomb
Three Mile Island
Three-Plus-Three Program
Threshold States
Threshold Test Ban Treaty (TTBT)
Tinian
Titan ICBMs
Tous Asimuts
Transporter-Erector-Launcher
Triad
Trident
Trinity Site, New Mexico
Tritium
Two-Man Rule

U-2
Underground Testing
Unilateral Initiative
United Nations Special Commission on Iraq (UNSCOM)
United States Air Force
United States Army
United States Navy
United States Nuclear Forces and Doctrine
Uranium

Verification

Warfighting Strategy
Warhead
Warsaw Pact
Wassenaar Arrangement
Weapons-Grade Material
Weapons of Mass Destruction (WMD)

X-Ray Laser

Yield

Zangger Committee
Zone of Peace

Introduction: Chemical and Biological Weapons

Eric A. Croddy

In the United States, there are various legal and academic definitions of weapons of mass destruction (WMD), although not everyone may agree on any of them. The U.S. Department of Defense (DOD) defines WMD as, "Weapons that are capable of a high order of destruction and/or of being used in such a manner as to destroy large numbers of people. Weapons of mass destruction can be high explosives or nuclear, biological, chemical, and radiological weapons, but exclude the means of transporting or propelling the weapon where such means is a separable and divisible part of the weapon."[1]

According to the DOD, conventional explosives also can be considered WMD. And this is reasonable, especially when one considers the cumulative number of deaths caused by gunpowder since its invention in the tenth century and by nitroglycerine since its invention in the nineteenth century.[2] But the underlying assumption of what makes a weapon massively destructive is the idea that these weapons can cause simultaneous mass casualties. Nuclear weapons (dealt with separately in Volume II) are an obvious category of WMD, but radiological weapons (such as so-called dirty bombs are less likely to cause mass injury or death (*see* Radiological Dispersal Device in volume II).[3]

Highly toxic chemical compounds—the nerve agents being prime candidates—could comprise WMD, for example, if delivered effectively against an urban target. Biological agents—that is, pathogens and toxins derived from plants or animals—might also constitute WMD if delivered efficiently. When compared to conventional and chemical weapons, biological agents have the greatest potential to cause mass casualties, and, theoretically, theirs could easily exceed the casualties caused by the largest nuclear weapon.

In terms of referring to nuclear, chemical—and by inference, biological—weapons, the term "weapons of mass destruction" first came into use in 1956 when it was used in a speech by Soviet Red Army Marshal Georgi Konstantinovich Zhukov. In fact, it was this speech that highlighted for U.S. policy makers the real or perceived threat from the Soviet Union, particularly in terms of the latter's presumed arsenal of chemical and biological weaponry. As such, Zhukov's speech invigorated United States Cold War research into WMD, including biological weaponry.[4] During the Cold War, the United States—and, to a much greater extent, the Soviet Union—amassed large chemical and biological weapons stockpiles. The threat posed by these stockpiles has diminished greatly since the crumbling of the Berlin wall.

Regional threats posed by state-funded militaries from chemical and biological weapons also have declined. By the end of 2003, the U.S. government had admitted that there was little evidence that Iraq had possessed large chemical or biological weapon stockpiles after the mid-1990s. This has since led both the United States and British governments to begin inquiries into the faulty prewar intelligence on Iraq that was in large part the basis for justifying Operation Iraqi Freedom in March 2003.[5]

Other regional threats, however, still remain. Among these, states such as Syria and North Korea are suspected of possessing chemical and biological weapons. Their bellicose posture regarding their immediate neighbors and regional rivals, as well as their possession of long-range delivery systems (such as Scud missiles), make these threats impossible to ignore. By contrast, Libyan leader Mohamar Qaddafi stated in early 2004 that he would renounce the possession of WMD, which demonstrates how quickly the threat of weapons of mass destruction seems to rise and fall on the global agenda.

Individuals and terrorist organizations also are reportedly interested in using chemical or biological agents in their operations. A salient example was a statement by a self-proclaimed spokesman for the terrorist organization al-Qaeda, who said in June 2002, "We have the right to kill 4 million Americans—2 million of them children—and to exile twice as many and wound and cripple hundreds of thousands. Furthermore, it is our right to fight them with chemical and biological weapons, so as to afflict them with the fatal maladies that have afflicted the Muslims because of the [Americans'] chemical and biological weapons."[6]

It is not clear as of this writing whether any individuals or groups will be able to carry out an attack using chemical or biological warfare agents, at least in a manner that could cause more deaths than the September 11, 2001, attacks on the World Trade Center (2,749 dead) and the Pentagon (184 dead). In 2001, the biological agent that causes anthrax killed five people when an unknown actor or group mailed *Bacillus anthracis* spores through the U.S. postal system. On February 3, 2004, envelopes containing ricin toxin were discovered at the office of the U.S. Senate majority leader and at a mail sorting facility for the White House. These incidents involving ricin resulted in no injuries, but justifiably caused much concern.

A Brief History of WMD

The historical record shows that mass poisonings and the occasional plot to spread disease among armies and civilian populations go back many centuries.[7] Still, chemical and biological warfare (CBW)—sometimes referred to in military parlance as "bugs and gas"—is essentially a modern phenomenon. It is modern in the sense that the science and industry required to produce these types of WMD have only existed since the early 1900s. However, there may indeed have been designs to use chemical or biological agents as a means of warfare (or possibly terrorism) before the Industrial Revolution. Before the late nineteenth century (the time of Louis Pasteur and many developments in chemistry), however, the requisite scientific knowledge and engineering capacity were insufficient to bring any such ideas to fruition. Obviously, this is no longer the case.

Many books and articles that discuss CBW often introduce the subject by bringing up past examples of chemical or biological warfare. In an excellent introduction to chemical weapons, a short book published by the Chinese People's Liberation Army discusses a case of CW (chemical warfare) from China's early history: In the *Zuochuan,* it is written that in the sixth century to about the fifth century B.C.E., "An official of the noble princes of the Xia, came from the Jin to attack the [forces of] Qin, and poisoned the Jing River, killing more than a division of men." Another case is cited: "In the year 1000 [C.E.], there was one named Tangfu, who made poison fire grenades and gave them to the Chao court of the Song dynasty. The poisonous smoke ball, containing arsenic oxide (As_2O_3) and a type of poison derived from crotonaldehyde (see the Arsenicals listing), looked a bit like a precursor to a chemical gas grenade. After alighting, this weapon would issue forth smoke to poison the enemy and thus weaken their ability to fight."[8]

These same authors also point out that this is a far cry from what one expects in modern times, for back then chemical warfare "was just in its infancy, and not only were its methods crude but its utility in actually killing people was limited. Because of this, chemical weapons were regarded as a method to generally assist in conducting warfare, and at the time did not draw any particular attention. Coming into the recent era, as the developments in technology continued, chemical weapons then really began to demonstrate their real menace."[9]

Another premodern military tactic that is often described as a form of BW (biological warfare) is the siege of Kaffa (1346 C.E.), in modern Feodosia, Ukraine. During a campaign by Mongol forces to defeat a heavily defended city of mostly Genoese merchants, bubonic plague struck the area: "The Tartars died as soon as the signs of disease appeared on their bodies: swellings in the armpit or groin caused by coagulating humors, followed by a putrid fever. The dying Tartars, stunned and stupefied by the immensity of the disaster brought about by the disease, and realizing that they had no hope of escape, lost interest in the siege. But they ordered corpses to be placed in catapults and lobbed into the city in the hope that the intolerable stench would kill everyone inside. . . ."[10] We note here that "stench" was considered in the pre-germ theory era to be responsible for disease. Thus, miasmas, "noxious effluvia," or "corrupt vapors" (*febres pestilentiales*) were synonymous with the spread of deadly epidemics—plague (causative organism: *Yersinia pestis*) being among the most notorious.[11]

The suggestion later made by historians that the Mongols were in fact able to spread bubonic plague by hurling disease-ridden corpses over the fortress walls is an intriguing one. During the fourteenth century, however, a germ theory of disease did not exist. How would the people of that era have known exactly how the disease could spread? What they could not have known is that bubonic plague is spread by fleas, which collect the bacteria *Yersinia pestis* (the causative organism of plague) through feeding upon infected rats. Fleas do not linger near the body once the temperature of the host (be it rodent or human) cools following death, making it rather unlikely that the cadavers would have done much to spread the plague. In the end, it was not the use of projectile cadavers, but more likely the exceptionally large rat population around the Black Sea that led to a pandemic throughout the region (and indeed much of Europe). One could probably conclude, however, that the Mongols did have the intent to spread disease among their enemy, and at least in this respect they conducted an early form of BW.

CBW in the Modern Era

The stunningly high rate of casualties that occurred in World War I had much do with the machine gun and rapid-fire artillery, but it also was caused in large part by the great number of men that were brought to the battlefields. World War I marks the emergence of "gas warfare:" the use of chlorine, phosgene, and other toxic chemicals. For the most part, these were used in vain attempts to achieve a breakthrough against well-defended armies in trenches. Later, chemical warfare agents such as sulfur mustard entered the scene when previous compounds were found to be less effective on the battlefield. Unlike chemicals used during the early stages of the conflict, mustard is not gaseous, but an oily liquid. It did not kill large numbers of troops, but it caused debilitating injury by irritating the skin, eyes, and upper airways. First used in 1917, it was responsible for the most injuries caused by chemical weapons during World War I.

Japan conducted CBW against China from 1937 to 1945. It is unknown whether the use of chemicals against Chinese soldiers gave the Japanese army a significant advantage on the battlefield. It is certain, however, that horrific BW experiments were conducted upon Chinese civilians and prisoners of war.[12] It is possible that some Allied soldiers, including American and British personnel, were experimented upon by Ishii Shiro (see the Sino-Japanese War listing) and his scientists, but this has not been confirmed. Apart from the East Asian theater of operations, however, no offensive use of CBW was conducted in World War II. Suggestions that the Soviet Red Army used tularemia (caused by the bacterium *Francisella tularensis*) against invading Nazi forces at the Stalingrad front are not supported by the available evidence.[13] German and Allied military scientists did pursue the manufacture of CW agents in very large quantities, but these never were used in conflict.

In the Korean War (1950–1953), Chinese officials, during armistice negotiations, accused the United States of using biological weapons. Although there is evidence that at least some of the communist Chinese leaders truly believed the allegations concerning BW in Korea[14], there is no evidence that the U.S. military used chemical or biological weapons during the conflict.[15]

During the Cold War, chemical agents became even deadlier. The United States and the Soviet Union stockpiled the German G-series nerve agents (sarin and soman), as well as the newer V-agents. Perhaps more dangerous was the development of weaponized biological agents. The United States and its allies during World War II had pursued a rudimentary offensive and defensive BW program. Later, work continued using a variety of infectious agents, including the causative organisms of anthrax, tularemia, and less deadly—but highly efficient—microbes such as Venezuelan equine encephalitis.

The controversy over the potential use of CBW grew increasingly protracted during the Vietnam War, particularly when the U.S. military used herbicides (such as Agent Orange) against Viet Cong-controlled areas. In a variety of instances, riot control agents (RCAs or tear gas) were used against the Viet Cong and Viet Minh regular army. Although such forms of weaponry were not intended to cause death, their use in an unpopular war heightened the sensitivity of the U.S. government to public perceptions of its CBW policies. As a consequence of Vietnam and high-profile incidents involving nerve agents at storage facilities in Utah and Okinawa, President Richard Nixon ended most U.S. chemical and biological programs in 1969.

When President Nixon renounced offensive BW and the United States stopped the production of biological weapons, the Soviet Union was only getting started. In 1979, a mysterious outbreak of anthrax in Sverdlovsk, Siberia (now Yekaterinberg) was suspected by Western intelligence to have been caused by a BW-related accident. (After many years of denials, Russia admitted in the 1990s that the Sverdlovsk outbreak was caused by Soviet military work with BW agents.) By the late 1980s, the Soviet BW apparatus (Biopreparat) had assembled the world's largest infrastructure devoted to the development of biological weapons. The Soviet arsenal included the standard agents, anthrax, tularemia, and a particularly virulent form of plague. But it had also weaponized smallpox, placing it in a liquid form to be delivered by intercontinental ballistic missiles.[16] Boris Yeltsin formally ended the program in 1992.[17]

Iraq had already used large amounts of chemical (but not biological) weapons against Iranian troops and Kurdish populations during its 1980–1988 conflict with Iran. After the first Gulf War (1990–1991), subsequent inspections conducted by United Nations personnel revealed that Iraq had undertaken a serious effort to develop chemical, biological, nuclear, and possibly radiological weapons. In 1995, the western world was particularly alarmed by the scope of the Iraqi BW program. Suspecting that Iraq had maintained at least a remnant of its WMD programs, including CBW agents and missile delivery systems, the United States led a war against Iraq beginning in 2003 that toppled the Iraqi regime. No caches of CBW agents have yet been found in Iraq by coalition forces since their occupation of Iraq.

The Chemical and Biological Threat Today

The world after September 11, 2001 has certainly changed, but even before then experts such as Michael Osterholm, Jessica Stern, and Jonathan Tucker had worried about the prospect that terrorists might obtain and use WMD. In 1993, Ramzi Yousef made the first attempt to destroy the World Trade Center. Yousef and his cohorts might have hoped that the towers would fall over in domino fashion, killing upwards of 250,000 people. Instead, the bomb they planted killed six people and injured more than 1,000. The attack failed to achieve the intended level of death and destruction, but it caused significant structural damage. Yousef reportedly considered the use of cyanide—a toxic "blood agent"—during the 1993 bombing. However, technical difficulties and other unknown factors prevented Yousef from designing such a device.[18]

There was another "wake-up call" to the threat of WMD, this time in Tokyo, Japan, when a guru named Shoko Asahara instructed followers to use nerve agents (sarin) against his real or perceived enemies. In 1995, Shoko Asahara's cult (Aum Shinrikyo) struck at the Tokyo authorities by releasing a nerve agent on the subway system. The death toll was 12, with thousands injured. The end result of the Tokyo subway attack was less than many experts expected from a WMD attack. Still, it made a tremendous impact, not only on Japanese society but also on how governments around the world reevaluated the CBW terrorist threat.

Improvised devices made by Palestinian terrorists using toxic chemicals have been a particular concern to Israel. But death and injury caused by shrapnel (ball bearings, nails, bolts, etc. made into projectiles by an exploding device) comprise the largest portion of the casualties inflicted by Palestinian suicide bombers. In 2002, however, it was reported that Israeli intelligence believed Palestinian homicide bombers to have put rat poison in their explosive devices. According to this assessment, terrorists put an anticoagulant type of rodenticide on shrapnel. Following bombings that occurred in 2002, Israeli doctors made note of excessive bleeding in certain bombing victims. This type of poison (warfarin) acts very slowly in mammals, making its utility and effect somewhat doubtful.[19] There is other evidence that Palestinian terrorists have been attempting to use other types of toxic chemicals in improvised explosive devices.[20]

Now that Saddam Hussein's Baath Party has lost control of Iraq and Libya has offered to abandon its WMD programs, there is a lower risk of seeing CBW on the battlefield among national armies. Syria and North Korea still retain a significant chemical weapons capability. But even skeptics of arms control treaties such as the 1993 Chemical Weapons Convention (CWC), the 1972 Biological and Toxin Weapons Convention (BTWC), and informal arrangements such as the Australia Group must concede that some progress has recently been made on the nonproliferation front. It is increasingly apparent that the world community has sustained the recent momentum toward the elimination of chemical and biological weapons, despite some notable setbacks.

Although the United States and other developed countries seem to be headed toward complete (if slow) chemical and biological disarmament, they continue to prepare their militaries for CBW defense in terms of materials and training. This is prudent, but one could make the argument that modern militaries are not likely to encounter chemical or biological weapons in organized combat. The more likely threat is from terrorists using toxic chemicals or infectious agents. This is unnerving, but terrorists have thus far made little effective use of these types of unconventional weapons. And yet, despite recent gains in the war against international terrorism, WMD will continue to pose a threat to society. It is difficult to conceive of a worse scenario than the effective use of chemical or biological weapons by terrorists who act with little or no restraint. By fostering an understanding of CBW agents, weapons, and their potential role in conflict, it is hoped that this volume will increase awareness—and vigilance—to defeat these threats.

Notes:

1. U.S. Department of Defense, Defense Technical Information Center (DTIC), December 2003, http://www.dtic.mil/.
2. Joseph Needham, *Science and Civilisation in China,* vol. 5, pt. 7: *Military Technology: The Gunpowder Epic* (New York: Cambridge University Press, 1986), p. 9. As a British diplomat (and to his death a committed Marxist), Needham was among the first to alert the world to Japan's use of chemical weapons against China during World War II.
3. A radiological dispersal device (RDD) or "dirty bomb" employs a high explosive (such as dynamite) to disperse radiological materials (such as cobalt–60, cesium–137, or strontium–90) across a large area. This would not result in a massive radiological hazard as no fission takes place. Rather, the contaminated area would likely remain off limits to people until it was fully cleared of radiating materials—a time-consuming and expensive process. The immediate effects of the explosion itself might of course cause death and injury, but few casualties would be expected from the radiological sources themselves. Nonetheless, the disproportionate (if somewhat justified) fear of "radiation" by the general public would no doubt cause great anxiety at the very least, perhaps even panic. Thus, RDDs are sometimes referred to as "weapons of mass disruption," as opposed to WMD.
4. William Patrick, "Biological Weapons Historical Overview," *Chemical & Biological Warfare Proliferation Course* (Washington, DC: Central Intelligence Agency, Biological Warfare Branch, December 1995).
5. Global Security Newswire, "Powell Says Knowing True Iraqi WMD Capability Might Have Affected War Decision," 3 February 2004, http://www.nti.org.
6. S. Abu Gheith, *In the Shadow of the Lances,* Middle East Research Institute, Special Dispatch Series no. 388, 12 June 2002, *http://memri.org/.*
7. Erhard Geissler and John Ellis van Courtland Moon, eds., *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945,* SIPRI Chemical & Biological Warfare Studies, No. 18 (Oxford, UK: Oxford University Press, 1999); James S. Ketchum and Frederick R. Sidell, "Incapacitating Agents," in Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz, *Textbook of Military Medicine, Part I: Warfare, Weaponry, and the Casualty: Medical Aspects of Chemical and Biological Warfare* (Borden Institute, Walter Reed Army Medical Center: Washington, D.C.: 1997) pp. 289–290.
8. Cheng Shuiting and Shi Zhiyuan, *Military Technology Information Handbook: Chemical Weapons,* second edition (Beijing: People's Liberation Army Press, 1999; second printing January 2000), p. 7.
9. Ibid.
10. Quoted in Mark Wheelis, "Biological Warfare before 1914," in Erhard Geissler and John Ellis van Courtland Moon, eds., *Biological and Toxin Weapons: Research, Development, and Use from the Middle Ages to 1945,* SIPRI Chemical & Biological Warfare Studies no. 18 (Oxford: Oxford University Press, 1999), p. 14.
11. Michael R. Gilchrist, "Disease & Infection in the American Civil War," *The American Biology Teacher,* vol. 60, no. 4, April 1998, p. 258.
12. Hal Gold, *Unit 731 Testimony.* Tokyo: Yen Books, 1996.
13. Eric Croddy and Sarka Krcalova, "Tularemia, Biological Warfare (BW), and the Battle for Stalingrad (1942–1943)," *Military Medicine,* vol. 166, no. 10, October 2001, pp. 837–838.

14. Chen Jian, *Mao's China and the Cold War* (Chapel Hill: University of North Carolina Press, 2001), p. 110.
15. "China's Role in the Chemical and Biological Disarmament Regimes," *The Nonproliferation Review,* vol. 9, no. 1, spring 2002, pp. 16–47.
16. Richard Preston, "The Bioweaponeers," *The New Yorker,* 9 March 1998, p. 63.
17. Ken Alibek, *Biohazard* (New York: Random House, 1998), p. 133.
18. John J. Parachini, "The World Trade Center Bombers (1993)," in John B. Tucker, ed., *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons* (Cambridge, MA: MIT Press, 2000), p. 201.
19. Sue Shaw and Jeremy Anderson, "Warfarin Ingestion," *Evidence Centre Report,* Monash Medical Center, Australia, 18 March 1999.
20. Andrew Chang, "Bombs and Bioterror," 6 August 2002, http://www.ABCnews.com.

Chronology: Chemical and Biological Weapons

Incidents of chemical or biological warfare (CBW) in history are of great interest, but they are also quite problematic—at least until we arrive at modern times (the post–World War I era). We say problematic because until the twentieth century, science had not sufficiently explained the roles of toxic chemicals or infectious disease in order to effectively utilize them in warfare. Nor had industry been developed in like fashion to exploit chemistry or biology for the purpose of waging battle. When it comes to chemical weaponry in particular, Augustin Prentiss put it quite well:

> History records numerous earlier but abortive attempts to utilize the powers of chemistry for military ends . . . .With the exception of Greek fire [use of petroleum-based incendiaries, ca. 7th century C.E.], none of them produced important results and none permanently challenged the supremacy of existing weapons. They are of interest to us only as indicating man's eagerness to experiment with any means that promise to promote his fortunes in battle and his final dependence upon technical knowledge to produce such means. (Prentiss, p. xvi)

Quite the same can be said of biological weaponry. In either case of chemical or biological weapons, the basic knowledge to understand the scientific disciplines behind them was inadequate until the nineteenth century, when significant advances were made in fields such as organic chemistry and microbiology. Still, it then took the latter stages of the Industrial Revolution for nations to develop the capacity for mass production of chemicals that would play a noteworthy—albeit overall insignificant—role in World War I (1914–1918).

Another criterion to consider is the scope of the purported attack. Was this a poisoning of a few individuals, or a whole army? Keeping in context with a weapon of mass destruction (WMD), that is, a device causing mass casualties, certainly not all events would necessarily qualify.

This will not stop us from trying to delineate a chronology of examples that are relevant to CBW. Here are listed a selection of historical events, with an effort to describe them by category: either chemical or biological weaponry.

Sixth Century B.C.	Assyrians reportedly used ergot fungus (*Claviceps purpurea*) to poison their enemy's water wells
431–404 B.C.	Spartan armies use sulfur and toxic arsenic smoke during Peloponnesian War
Fourth Century B.C.	Chinese engineers use arsenic against underground sappers.
Circa 200 B.C.	Officers in Hannibal's army adulterate the wine of African rebels with mandrake, which contains belladonna alkaloids causing hallucinations.
187 B.C.	Ambraciots (Greece) employ irritating smoke against Roman soldiers
7th Century C.E.	The Byzantine architect, Callinicus ("Kallinikos"), reportedly invents the first

	liquid incendiary—"Greek Fire."
Circa 1040	Scottish king poisons wine using a belladonna-like ("sleepy nightshade") herb and gives to Norwegian enemies as "provisions" under pretense of surrender. Scots then slaughter the incapacitated Norwegians.
1347	Mongolians lay siege to Kaffa (in modern Ukraine) and throw corpses over city walls to spread bubonic plague. May have contributed to Black Death, which killed approximately 50 million people through the fourteenth century.
1672	Bishop of Münster attempted the use of atropine-like drug in grenades in siege against city of Groningen. Attack backfires.
1767	British plot to supply cloths from a smallpox hospital ward to American Indian tribes in hopes of spreading disease. Unknown if this strategy was ultimately successful.
1855	Sir Lyon Playfair suggests using cyanide-containing chemicals against Russian troops during Crimean War, but this tactic never found approval by the British High Command.
29 July 1899	First Hague Convention signed, prohibiting "the use of projectiles the sole object of which is the diffusion of asphyxiating or deleterious gases." (Mauroni, p. 81)
1914	French troops use tear gas grenades against German positions in World War I
22 April 1915	German military uses barrage of chlorine gas against Allied trenches in Ypres, Belgium.
12 July 1917	Germany uses mustard agent against Allied troops at Ypres, Belgium.
1916–1918	German agents infect beasts of burden—including horses bound for use by Allies in Europe—using glanders and anthrax.
1919	In midst of the Russian civil war, British troops use adamsite (diphenylaminearsine, DM) against Bolsheviks.
1922	The U.S. delegates at the Washington Arms Conference table a proposal to abolish chemical warfare, but France ultimately rejects the treaty because of stipulations regarding submarines.
17 June 1925	Geneva Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or other gases, and of Bacteriological Methods of Warfare is signed by nearly thirty countries.
1936	German chemists synthesize first nerve agents to be weaponized, including tabun (GA).

1937–1942	During Sino-Japanese War, Japan employs chemical and biological weapons against Chinese troops and civilians.
1939	Japanese attempt to poison water with *Salmonella enterica* Typhi (causative agent in typhoid) in the so-called Nomonhon Incident in a biological attack on Soviet troops, but apparently is unsuccessful.
1935	Italian troops under Benito Mussolini begin using chemical weapons (mustard agent) against Ethiopians.
1942	United States undertakes study of biological warfare (BW) agents, including defensive and offensive preparations.
December 1943	German Luftwaffe attacks Allied ships carrying sulfur mustard in Bari, Italy, leading to more than 600 casualties.
1956	Soviet Marshal and Defense Minister Georgy Zhukov mentions the use of "various means of mass destruction, such as atomic, thermonuclear, chemical and bacteriological weapons," stirring great interest and anxiety in the West. (Mauroni, p. 85)
1962	The U.S. military begins herbicide operations in Vietnam War, including the use of Agent Orange.
1965	As the war in Vietnam escalates, the United States employs riot control agents—chiefly CS—in certain military operations, creating controversy, especially for war critics at home and abroad.
1967	With possible support from the Soviet Union, Egyptian forces use chemical weapons, including mustard agent and some kind of organophosphate (nerve agent) against Yemeni royalists.
25 November 1969	U.S. president Richard M. Nixon renounces the offensive use of biological weapons, ordering that the U.S. program be dismantled.
10 April 1972	Great Britain, the Soviet Union, and the United States sign the Biological and Toxin Weapons Convention.
1973	Following the Yom Kippur War (fought between Israel and Arab countries), U.S. military analysts discover that Egypt possessed armored vehicles equipped with protection against nuclear, chemical, and biological (NBC) warfare. This leads to concern that Warsaw Pact forces, supported by the Soviet Union, were prepared to use NBC weapons.
1973–1974	The Soviet Union initiates and establishes Biopreparat, a civilian organization devoted to producing biological warfare agents.

26 March 1975	The Biological and Toxin Weapons Convention enters into force.
1979	Anthrax (*Bacillus anthracis*) spores are accidentally released from a biological weapons facility in Sverdlovsk, Russia; at least 64 people died from inhalation anthrax.
1983	Iraq begins using chemical warfare agents, including mustard, in the Iran-Iraq War (1980–1988).
January–March 1991	A United States–led coalition invades Iraq in Operation Desert Storm. The goal is to force Iraqi compliance with United Nations resolutions calling for its withdrawal from Kuwait and elimination of its weapons of mass destruction (WMD) programs. A newly formed United Nations Special Commission on Iraq (UNSCOM) searches for WMD and oversees the destruction of known chemical and biological weapons arsenals and production facilities until 1998, when Iraq defies international mandates and forces UNSCOM inspectors to leave the country.
13 January 1993	The Chemical Weapons Convention (CWC) is open for signature.
26 February 1993	On 26 February 1993, a small group of men from the Middle East with suspected links to the terrorist organization al-Qaeda detonate 1,500 pounds of explosive in the basement of the World Trade Center in New York. The attack does not destroy the buildings, but kills six people and injures more than one thousand. Concerns arise over the possibility that the terrorists laced the high explosives with chemical weapons in order to increase the number of casualties.
27 June 1994	Aum Shinrikyo, a new religious cult in Japan, uses sarin nerve agent in an assassination attempt on three judges in Matsumoto, killing seven people and injuring over 200.
20 March 1995	Aum Shinrikyo releases sarin nerve agent on the Tokyo subway, killing 12 people and injuring about 1,000. Japanese police discover nerve agent precursors at the cult's home base near Mt. Fuji and also learn that Aum attempted to produce biological weapons.
19 April 1995	Timothy McVeigh detonates a 4,000-pound ammonium nitrate fuel oil (ANFO) explosive device in a rented truck, destroying the Alfred P. Murrah Federal Building in Oklahoma City, Oklahoma and killing 168 people.
29 April 1997	The CWC enters into force.

October 2001	A still unknown perpetrator mails four letters containing anthrax spores to unsuspecting victims in Florida, New York, and two U.S. senators in Washington, D.C. Five people eventually die of inhalation anthrax, while seventeen others—having contracted either inhalation or cutaneous forms of the disease—are treated successfully.	
March–April 2003	Led by the United States, coalition forces undertake Operation Iraqi Freedom, with the stated goal of ridding Iraq of its weapons of mass destruction (WMD) programs.	

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A

ABERDEEN PROVING GROUND

Established in October 1917, Aberdeen Proving Ground in Maryland is the oldest active location in the United States for the design and testing of munitions and protective military equipment. During World War I, Edgewood Arsenal, the northern area of the proving ground, was the primary location in the United States for chemical weapons research, development, production, and testing. Aberdeen Proving Ground was also the center of United States offensive chemical weapons operations until production of chemical warfare (CW) agents in the United States ended in 1968.

Among the chemical agents the Edgewood facility produced (in ton quantities) were the choking agents phosgene and chloropicrin, the blister agent mustard, and the nerve agent sarin (*see* Choking Agents, Mustard [military code: HD, for mustard, "H," distilled, "D"], Sarin [GB, for "German" nerve agent type, "B," second in series]). Throughout the decades of the U.S. chemical weapons program, Aberdeen Proving Ground also has been central to defensive chemical activities. Aberdeen is home to the U.S. Army Soldier and Biological Chemical Command (SBCCOM), the Program Manager for Chemical Demilitarization, and the U.S. Army Medical Research Institute of Chemical Defense (USAMRICD). Finally, the Aberdeen Chemical Agent Disposal Facility will dispose of 5 percent of the original stockpile of United States chemical weapons, which is currently being stored at Edgewood, by 2006–2007 (*see* Demilitarization of Chemical and Biological Agents).

The Chemical Warfare Service (CWS) was created in 1918 to oversee all United States chemical weapons activities; during World War I, Edgewood Arsenal was the home of offensive weapons production by CWS that comprised four production plants and four munitions-filling plants. In the interwar years, almost all CWS activities were transferred to Edgewood, where the emphasis shifted from agent production to defensive research and development and chemical defense training for troops. During World War II, President Franklin Roosevelt condemned Japan's use of chemical weapons in China, but he reserved the right to respond in kind if such an attack were launched on the Allies. This resulted in a military requirement spurring more chemical weapons activity at Edgewood. But with the exception of Japanese chemical weapons used in China (1937–1943), and possible use of cyanide grenades against Allied soldiers in the Pacific, no other actor in World War II utilized chemical weapons on the battlefield. The only U.S. chemical casualties suffered during World War II were accidental (*see* Bari Incident).

Following World War II, Edgewood continued to be the center for U.S. chemical weapons research, serving as the site for pilot production of the nerve agent sarin. In 1969, however, President Richard Nixon stopped U.S. chemical weapons production, and on November 25 he announced that he would resubmit the 1925 Geneva Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous, or Other Gases, and of Bacteriological Methods of Warfare to the Senate for ratification (it had been rejected in 1926). The U.S. Senate, however, did not ratify the Geneva Protocol until the subsequent Ford administration (1975).

Throughout its history, Edgewood has played a key role in defensive chemical weapons efforts, from development and testing of gas masks and other protective equipment, to researching and developing medical treatments for chemical weapons casualties. When destruction of the U.S. chemical weapons stockpile began in earnest by the 1990s, Edgewood became home to both the Program Manager for Chemical Demilitarization (the office overseeing U.S. destruction efforts), and the Chemical Demilitarization Training Facility, where personnel responsible for operating destruction facilities are trained. Destruction of 1,818 one-ton containers of mustard will take place at the Aberdeen Chemical Agent Disposal Facility beginning in 2004. This disposal will be conducted by first using chemicals to neutralize the agent. Afterward, the hazardous waste products generated will be detoxified by sewage treatment bacteria at an off-site commercial facility.

—*Claudine McCarthy*

See also: Demilitarization of Chemical and Biological Agents; United States Chemical and Biological Weapons Programs; World War I; World War II: Chemical Weapons

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ABRIN

Abrin is a highly toxic protein that can be used as a poison. But like ricin (a toxin found in the castor bean plant, *Ricinus communis*), abrin is more likely to be used as a poison for murder or for assassinating certain targets than as a component in a weapon of mass destruction (WMD).

Abrin can be extracted from the seeds of the *Abrus precatorius* plant, the beans of which are known as Rosary peas, precatory beans, crab's eye, or the jequirity bean. Provided the bean is well masticated, one such seed from this plant can be enough to kill a human adult. Both abrin and ricin (another plant lectin) share similar structures, toxicological properties, and approximately the same molecular weight (60,000 and 65,000, respectively). Research conducted in the 1970s demonstrated that abrin was approximately 2.5 times more toxic than ricin when administered to mice. Due to the much larger market for castor beans (as a source for vegetable oil and for use in lubricants), the worldwide availability of jequirity seeds is relatively small. As a consequence, and despite the disparity in their toxicities, ricin probably remains a greater overall threat.

The abrin toxin itself consists of a large protein chain. Like ricin toxin, the abrin protein attaches itself to a cell with its B portion, and the A segment inserts itself into the ribosome, stopping protein synthesis. This leads to cell death and causes nausea, vomiting, and shock. If abrin particles are inhaled, abrin can cause the death of tissue in the lungs and airways, leading to severe inflammation and edema. Death from abrin poisoning would likely occur many hours after exposure.

In a military manual published by members of the al-Qaeda terrorist organization (circa 2000), the reader is instructed that precatory beans ("red or black and used in prayer beads") could be used to extract abrin for assassination purposes. The recipe described in the manual was probably derived from *The Poisoner's Handbook,* an underground pamphlet published in the 1980s.

—*Eric A. Croddy*

See also: Al-Qaeda; Bioterrorism; Ricin

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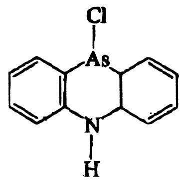
ADAMSITE (DM, DIPHENYLAMINO-CHLORARSINE)

The chemical agent adamsite falls between the categories of moderately toxic chemical warfare (CW) agent and riot control agent (RCA). For adamsite to be used as a WMD, large quantities would be required, and such a scenario seems implausible. In enclosed spaces, however, many people could be affected by a release of adamsite. According to a Chinese military book on chemical weaponry, the United States used adamsite in the Korean War (1950–1953), probably a reference to the use of tear gas—which included adamsite at the time—used to control rioting Chinese and North Korean POWs. Today, no known modern military stocks significant amounts of this chemical. Still, large quantities may remain (most likely in Russia) in existence, awaiting destruction as an old chemical weapon (produced prior to 1946).

Figure A-1: Adamsite



Adamsite (DM)

The German chemist Heinrich Wieland is credited with having synthesized diphenylaminochlorarsine in 1915. Three years later in the United States, Major Roger Adams also synthesized this compound while conducting his own independent research. Thereafter, the U.S. military referred to this chemical as adamsite. During the early twentieth century, rapid advances in organic chemistry—including the mass production of dye-base precursors such as diphenylamine—made adamsite relatively easy to manufacture in large quantities. Reportedly, in 1919, the British employed adamsite against Bolshevik forces during the Russian Civil War. During its war against China in World War II, Japan used large quantities of related compounds such as diphenylcyanoarsine, and Japan may also have used adamsite.

Adamsite is a yellowish, crystalline solid that can be delivered by means of generating smoke with high heat. Adamsite can also be delivered in the form of a liquid (dissolved in solvent) or fine powder. As the term *vomiting agent* suggests, adamsite has been known to cause severe nausea, although it is not entirely clear why it has this effect in humans. Adamsite also has been referred to as a sneeze gas (sternutator) and an irritant smoke. Unlike other types of RCAs, the effects of adamsite—which include severe irritation of the upper respiratory tract—are delayed by at least several minutes. Adamsite is practically odorless, and this, coupled with its ability to break through the protective masks of the era, was another feature that has made adamsite a potentially insidious and effective CW agent. In the United States military, adamsite was originally designed to be delivered in the M6A1 grenade. The same Chinese military text referred to above describes a former Soviet munition that employed adamsite: "The former Soviet [KRAV-25] chemical munition is filled with 2.7 kg of adamsite, producing a vapor for about 9–10 minutes. The casualty-causing effects of its shrapnel and explosive force are about the same as conventional munitions. This type of CW ordnance is often used intermixed with conventional munitions to produce disorder and exhaustion on the battlefield" (p. 26).

There are numerous toxicological studies, but most are based on animal experimentation, and therefore it is difficult to arrive at a precise lethal dose for adamsite in humans. An accidental death was reported in one individual who was exposed to an estimated 1,000–2,000 milligrams per cubic meter of air (mg/m^3) concentration of adamsite for 5–30 minutes. The estimated median lethal concentration of adamsite is 11 gramsmin/m^3, a toxicity which pales in comparison to that of most other CW agents. But adamsite is far more toxic than other RCAs such as CS tear gas (*see* Riot Control Agents). CS is designator for the tear gas after its inventors and chloroacetophenon (CN), both used by civilian and military detachments for quelling public disturbances.

—Eric A. Croddy

See also: Arsenicals; Riot Control Agents

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AEROSOL

When it comes to the delivery of chemical or biological warfare (CBW) agents, understanding the physical and chemical qualities of toxic or infectious substances is crucial. One of the most important factors in delivering CBW agents is the formation of aerosols. In nuclear warfare, aerosols represent a threat in the form of radioactive fallout. In conventional weaponry, fuel-air munitions (thermobaric weapons) can employ liquid fuel in the form of an aerosol that, upon ignition, causes great destruction over a wide area.

Although their behavior in the atmosphere may share similarities, aerosols are to be distinguished from gases and vapors. A gas is an amorphous, molecular form of matter. Vapors are those gases that evolve from liquids, especially those that are in liquid form at room temperature. Water vapor, for example, evaporates from water and can condense back into liquid. An aerosol can be briefly described as a suspension of tiny particles in air, these particles being either liquids or solids. Although some scientific disciplines have set strict guidelines on what makes a true aerosol, aerosols generally are airborne particles that stay aloft in the atmosphere for a certain period of time.

Smoke, mist, and fogs are examples of aerosols consisting of very small (0.25 microns) to relatively large (40 microns) particles. (A fog is essentially a cloud formed by particles with water droplets adhering to them.) With strong light and a dark background, the human eye can see floating particles in the air of about 30 microns in size. (For comparison, human hairs have an average diameter of 75 microns.) Atmospheric haze is thought to be largely caused by particles of approximately 0.1 microns or even smaller. Objects that are less than 0.2 microns cannot be seen even with light microscopy. Common substances that can form aerosols are listed in the table below.

Table A-1: Representative Particle Sizes

Some example particle sizes	*Diameter, microns*
Tobacco smoke	0.25
Flour dust	15–20
Pollens	15–70
Talc powder	10

The word *aerosol* itself is a throwback to World War I, when Professor F. G. Donnan first coined the word. An aerosol in the older context referred to the behavior of irritating arsenical smokes. Today, the science of aerosols has involved many disciplines, not the least of which concerns biological materials that exist in the air. Bioaerosol research involves, among many other things, the characterization of allergens (such as pollen) and infectious organisms (such as fungi) and how these affect human health. Chemical-based aerosols are, of course, very relevant when assessing risks from industrial and household pollutants.

Aerosols consist of particles that fall out of the atmosphere, but at a low rate of speed. Although gravity dictates that all particles must drop to the ground, their fall is influenced by the atmospheric interferences and aerodynamic fluctuations of variously sized particles. The chart below shows the relative rates of fall among particles ranging from 0.2 microns to 1 millimeter in diameter.

Table A-2: Particle Fall Rate at 20 Degrees Celsius

Diameter (microns)	*Weight (microgram)*	*Terminal velocity (cm/min)*
0.2	4.2×10^{-9}	0.014
0.5	6.5×10^{-8}	.06
1	5.2×10^{-7}	.21
2	4.2×10^{-6}	.77
3	1.4×10^{-5}	1.6
5	6.5×10^{-5}	4.7
10	5.2×10^{-4}	18
20	4.2×10^{-3}	72
30	1.4×10^{-2}	162
51	6.5×10^{-2}	432
100	5.2×10^{-1}	1,500
200	4.2	4,200
300	14	6,900
500	65	12,000
1,000 [1mm]	525 [.525 mg]	23,100

Brownian movement—motion of tiny particles caused by the ongoing dynamics at the molecular level—thermal forces, electrostatic charges, and other factors affect aerosol stability. However, when looking at the larger picture, wind and atmospheric changes as well as precipitation dramatically influence the nature of aerosols in a variety of contexts.

The utilization of aerosols is important for maximizing concentrations of chemical and biological warfare (CBW) agents. Whether chemical or biological, aerosols can be delivered in two basic forms: line source and point source. A line source can be visualized by using the crop duster model: Aerosols are released from a moving platform, an object that draws a line of cloud in its wake. Wind moving perpendicular to this line source can then spread the aerosol over a large swath of territory. Point sources rely on single bursts or from releases from a static position. After point release via spray or detonation with an explosive, air currents can carry these agents to saturate nearby targets. Point sources usually require redundant applications to achieve wider area coverage.

Because their behavior is similar to that of gases, aerosols are greatly influenced by wind velocity and thermal convection currents. CBW agents generally increase their effectiveness as a function of concentration (particles or milligrams of liquid per cubic meter of air, etc.) and time. The longer an aerosolized agent remains on target, while maintaining a high enough concentration to cause infection (if a biological weapon) or injury (if a chemical weapon), the more casualties will result. Therefore, conditions of stable air with little mixing of different temperature layers are ideal for disseminating aerosolized agents. Such a state is referred to as an inversion. An inversion is characterized by little vertical movement of air, and it usually occurs near dusk or dawn. Aided by low wind velocity, CBW agent aerosols released under these conditions will linger over the ground and stay relatively concentrated over time. Less ideal are conditions described as neutral, with little change in air temperature as one reaches higher altitudes. Here, winds are often stronger, with minor convection currents. Finally, air instability in the lapse phase is least ideal for aerosol delivery. Not only are the horizontal winds in this situation unfavorable, but strong vertical gusts of air break up and dissipate aerosols.

In chemical warfare (CW), the primary challenge in delivering toxic substances on the battlefield is to create concentrations high enough to cause a large number of casualties. Gases such as chlorine and phosgene can expand quickly over an area, but they also disperse just as rapidly, reducing their toxic effects. Even those CW agents that are volatile liquids present significant challenges to effective delivery. They do not form vapors quickly enough or in dense enough format to be effective. Therefore, modern CW has included the use of aerosols to maximize the effectiveness of delivery of toxic agents on the battlefield. By means of toxic aerosols, CW agents are more widely dispersed, and under favorable meteorological conditions, they remain in high concentration over time.

Chemical aerosols can be produced by means of explosive munitions, such as artillery shells or aerial bombs, or through the use of spray tanks with specially fitted nozzles. When aerosols are produced by explosion, a certain amount of agent will be destroyed in the detonation energy and possible conflagration. Loss of CW agent is not expected to be much more than 25 percent, however. A Chinese People's Liberation Army book on chemical weaponry describes the percentages of droplets, aerosol, and destroyed agent in a U.S. chemical munition in the following way: "In the case of the U.S. 155 mm VX explosive [howitzer] shell, about 60 percent of the agent is scattered within a 20 meter area, 15 percent being disseminated in an aerosol that floats downwind from the point of detonation in the air. The remaining CW agent is destroyed due to the blast."

Especially in the case of biological warfare (BW), aerosols are most effective when their average particle sizes fall between about 1 and 10 microns. Using experimental animals and corn oil droplets, early research conducted by the United States BW program in the 1950s showed the relationship of particle diameter to particles' ultimate fate in a model respiratory system (see table below).

Particles that can effectively reach down into the lungs and deposit in the alveoli—tiny air sacs where gas exchange takes place between the lung and the bloodstream—are absorbed more quickly. The

Table A-3: Experimental Distribution of Corn Oil Particles in Mice Lungs

Size microns (Particle diameter)	*% Lung (Number of particles found)*	*% Bronchi (Number of particles found)*	*% Terminal Bronchi and alveoli ducts (Number of particles found)*	*% Alveoli (Number of particles found)*
0.8–2.5	80	24	26	30
3.3–10	19	10	7	2
12–17	1	0	0	0
Total	100	34	33	32

highest alveolar deposition is for particles from 1 to 5 microns in diameter. Much smaller particles (such as the main constituent of tobacco smoke) can be so small that they are inhaled and exhaled without landing upon inner surfaces of the bronchi or lungs. Those particles 10 microns or larger become more prone to barriers in the respiratory system, depositing on hairs in the upper airways or bronchial tree. For some agents, such as mustard, however, large particles will cause severe tissue damage in the higher regions of the throat, causing death from respiratory blockage due to subsequent formation of dead tissue. With its predilection for membrane solubility, VX nerve agent will absorb into skin and upper tissues in the respiratory tract. Thus, even if the particles are not dispersed in the size of 1–5 microns, chemical casualties will still likely occur for unprotected individuals. The only difference may be the time before onset and the degree of severity.

Table A-4: Particle Size and Deposition in the Human Respiratory System

Particle diameter	*Areas where deposition is most likely to occur*
Larger than 10 microns	Throat and nasal passages
5 to 10 microns	Upper to lower respiratory tract
2 to 5 microns	Lung and bronchioles
Less than 2 microns	Alveoli

For biological weapons, average particle sizes are even more important, as most, if not all, modern applications of BW agents—save the dermally active trichothecene mycotoxins—utilize inhalation to cause injury or death. With some notable exceptions, the deliberate cause of disease through inhalation—the essence of BW—is best achieved by alveolar deposition of infectious particles. Experiments with animals and with human volunteers have shown the direct relationship between optimal particle size and the chances for infection to start via the lungs.

Even more so than chemical weapons, biological agents are difficult to disseminate efficiently in aerosols for creating large casualties. First, BW agents are sensitive to heat and violent shock. Production of aerosols by means of explosive devices is likely to kill 99 percent or more of the BW agent. Therefore, to expect battlefield success, bacteria, viruses, or toxins must be prepared in such a way that enough infectious or toxic doses remain effective following detonation. Second, the formulation of BW agents to retain shelf life and virulence—as well as having the right physical properties to create effective aerosols—takes considerable expertise and development. Finally, the controlled release of aerosolized particles that fit the "sweet spot," that is, in the 1–5 micron average diameter range, has been a difficult hurdle even for advanced BW programs.

In more conventional types of weaponry, aerosolized explosives can be used to create devastation. In the case of fuel-air munitions (or fuel-air explosives, FAE), combustible fuels can be aerosolized over a target and detonated, causing a massive detonation with significant overpressures. So-called thermobaric munitions can employ a highly flammable liquid/vapor such as ethylene oxide or propylene oxide. These large munitions are normally dropped from aircraft, their rate of fall slowed by parachute, and their contents released over a large area. After a delay, this aerosol is detonated with another charge that, after the cloud has formed something of a pancake shape, ignites the

Table A-5: Bacteria Required to Create Medical Conditions

Particles, diameter (microns)	*Number of bacteria required to cause infection/Respiratory virulence (RLD_{50}) Guinea pig* Francisella tularensis	*Number of bacteria required to cause infection/Respiratory virulence (RLD_{50}) Rhesus monkey* Francisella tularensis	*Number of bacteria required to cause infection/Respiratory virulence (RLD_{50})* Francisella tularensis *Human volunteers, infectious dose (ID_{50}, nonfatal)*
1	2.5	14	10–52
6.5	4,700	178	14–162
11.5	23,000	672	NA
18	125,000	3447	NA
22	230,000	More than 8,500	NA

cloud in a very large blast. One can compare the large force involved in grain elevator explosions, in which small quantities of grain dust are ignited by a spark, which leads to a massive blast. In a thermobaric device using aerosols, the resultant explosion creates very large overpressures capable of flattening structures in the immediate blast zone and causing considerable damage on the periphery. In addition to targeting troop concentrations, this type of aerosolized fuel-air munition has found a role in clearing land mines. Both the United States and Chinese militaries, for example, have fielded such systems for land mine removal.

—Eric A. Croddy

See also: Biological Warfare; Chemical Warfare; Fuel-Air Explosive; Line Source; Point Source

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AGENT ORANGE

Agent Orange was the name given to one type of chemical herbicide used by the U.S. military during the Vietnam War. The 1993 Chemical Weapons Convention prohibits the use of herbicides as a means of warfare. The United States, however, has reserved the right to use these chemicals for weed control at airfields, for example, and in limited amounts for security of its armed forces. Herbicides are included in this discussion on WMD not only because of the controversy surrounding their use, but also because of their capacity to cause extensive destruction to forests and jungle. Although the short-term environmental effects can be devastating, most herbicides (when used correctly) have little or no deleterious effect on human health. The same also can be said of Agent Orange.

Spraying liquid herbicides in large quantities from aerial applicators (such as crop dusters) was a pre-World War II idea. In the 1930s, the U.S. Army Air Corps refined techniques that would prove useful for the application of DDT, one of the most successful insecticides ever developed. During World War II, the U.S. Army aggressively pursued research into producing compounds that could destroy plants. More than 1,000 different compounds were investigated at Camp Detrick, Maryland. One chemical code-named LN-8 stood out from the rest. This formulation, 2,4-dichlorophenoxyacetic acid, or 2,4-D, proved to be one of the most effective herbicides ever synthesized. It is still a widely used herbicide for weed control and other agrochemical applications.

Highly effective herbicides based on the phenoxyacetic acids (chiefly 2,4-D) were tested at bombing ranges in Texas and Indiana during World War II. These trials were so successful that U.S. military planners considered the use of herbicides against the Japanese during the war in the Pacific. The strategy would involve using herbicides to mark the jungle, leaving lines of dead foliage to guide bombers to Japanese troop concentrations. This stratagem and other plans that included attacking Japanese rice crops in preparation of a final invasion, however, were eventually tabled.

During the Korean War (1950–1953), the U.S. Air Force made operational plans to use 2,4-D herbicide with 2,4,5-T (which would eventually be called Agent Orange during the Vietnam War) to destroy vegetation that could be of use to the enemy. The plan was never implemented because the ecology of the Korean peninsula was entirely different from that of tropical zones, and there was no perceived benefit in the use of herbicides in that conflict. Spraying equipment that was initially shipped to Korea was put in storage, and the chemical agents were destroyed in 1955.

While fighting against Malaysian communist insurgents at about the same time, the British military used trioxene and diesolene herbicides against enemy crops. Some operational lessons from this conflict were useful for future U.S. military engagements. In the late 1950s, artillery range exercises in the United States were hampered with overgrowth, and Dr. James W. Brown was brought in from the U.S. Army Biological Warfare Laboratories to devise a solution to the problem. He supervised the aerial spraying of sugar maples using a combination of 2,4-D and 2,4,5-T. These practical experiences led to the use of this mixture in the Vietnam War, especially during the years 1961–1971.

As the United States became more actively involved in the South Vietnamese struggle against communist forces, herbicides were considered for use against enemy cover and food. South Vietnamese President Ngo Dinh Diem and his brother Ngo Dinh Nhu were enthusiastic supporters of defoliation operations. President John F. Kennedy and the U.S. Joint Chiefs of Staffs, however, recalled how Chinese communist propaganda had (falsely) accused the use by the United States of chemical and biological warfare against North Korea a decade earlier. Before authorizing the use of herbicides in Vietnam, then, the Kennedy administration first looked into the legality of such a venture. In 1961, Secretary of State Dean Rusk assured President Kennedy that the use of defoliant did not violate international law concerning CW and was an accepted tactic of war. Still, the use of herbicides in warfare, along with the use of tear gas (CS) and napalm, drew criticism from both international and domestic circles.

Although the U.S. Air Force employed a number of herbicide formulations during the Vietnam War, Agent Orange was used in the greatest quantity and was arguably the most effective.

Table A-6: Representative Herbicides Used in South Vietnam, 1965–1971

Herbicide	*Gallons*
Orange (2,4-D and 2,4,5-T phenoxyacetic acids)	10,645,904
White (80% 2,4-D and 20% picloram)	5,632,904
Blue (cacodylic acid)	1,144,746

The U.S. Air Force conducted a massive defoliant campaign in Vietnam called Operation Ranch Hand. The initial goal of the herbicide program in Vietnam (and also in neighboring Laos) was to deny the enemy protective cover, especially along the borders with North Vietnam, and to eliminate manioc (tapioca) groves that were being used by the Viet Cong guerillas for both cover and as a food source. Less than 10 percent of the herbicides used in Vietnam and Laos were directed against enemy crops, the remainder being used to clear fields of fire for finding and fixing the enemy, and to maintain security around military facilities by removing vegetation that obscured sightlines. Results of the herbicide campaign were mixed. Some studies showed that the Viet Cong were hard pressed to make up for the food shortages caused by the operation, but others found Operation Ranch Hand to be politically and militarily counterproductive.

The United States eventually abandoned the South Vietnamese, and it may be impossible to assess fully the merits or demerits of Operation Ranch Hand. The ecological aftermath of Operation Ranch Hand also offers a mixed picture. Most of the devastation occurred primarily in the mangrove forests; some estimates claim that it will require 100 years for the forests to grow back. But most other areas recovered within about a year after the last spraying sorties.

Following the Vietnam War, many U.S. veterans claimed that they suffered illness due to exposure to Agent Orange. Studies subsequently found that dioxin, a highly toxic and carcinogenic substance, was present in small concentrations within Agent Orange. No scientific evidence, however, has thus far been able to link Agent Orange and very small concentrations of dioxin to significant human disease.

—Eric A. Croddy

See also: Dioxin; Herbicides; Vietnam War

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AGROTERRORISM (AGRICULTURAL BIOLOGICAL WARFARE)

Agroterrorism, or agricultural BW, is also referred to as agricultural bioterrorism. None of these terms, however, seem to discriminate between military programs and smaller, less sophisticated attacks on a food supply (e.g., bioterrorism or sabotage). Still, they are interchangeably understood to mean the deliberate use of pathogens against crops or livestock. The social and economic consequences of a concerted agroterrorist attack could be quite extensive. Because industrialized countries are increasingly dependent upon large-scale, dense, and efficient mechanized farms, there is an acute vulnerability to deliberate attack using plant or animal pathogens. Such attacks could cause huge economic losses.

Vulnerability of Livestock

For example, Newcastle disease (caused by a virus) primarily affects birds, resulting in severe illness with a high mortality rate (between 95 and 100 percent). Humans can also be infected with the Newcastle disease virus (though the disease is relatively benign in humans, unlike in birds), and it is possible for people to spread the virus to animals. In 1971, southern California experienced a Newcastle disease outbreak that led to the slaughter of 12 million chickens in an effort to control its spread. Another serious epizootic, avian influenza virus (fowl plague), has been known to jump from one species, such as fowl or pig, to humans (and vice versa). In 1983–1984, an outbreak of avian influenza (H5N5 strain) in Pennsylvania led to a campaign to destroy all infected birds in the vicinity. As a result, prices for poultry rose some $350 million that year. Another strain of avian influenza, H5N1, killed six people in Hong Kong in 1997, also demonstrating the virus's ability (albeit rare) to jump from one species to another.

In one of the most serious animal disease outbreaks to occur in the previous century, foot-and-mouth disease (FMD) in 1997 devastated Taiwan's swine industry, leading to some $25 billion in direct and indirect losses to the country's economy. Although FMD is not nearly as deadly to animals as other diseases such as rinderpest, a deadly viral disease that can wipe out whole herds of cattle, it is still among the most feared disease in agriculture, especially in the cattle and swine industries. The disease generally results in many sick and, therefore unproductive, animals. In addition to fever, anorexia, and general malaise, infected animals manifest blister-like sores on and inside the oral cavity and on the teats, as well as ulcerating patches on the hooves (thus the name *foot-and-mouth*). The 1997 outbreak probably began with the smuggling of an infected animal across the Taiwan Straits from mainland China. Although some have suggested this was a deliberate attack perpetrated by the Chinese, most Taiwanese veterinarians believe it was unintentional. Another outbreak of FMD a few years later, this time in the United Kingdom, also led to billions of dollars in economic losses, primarily in the sheep rearing industry. These examples of natural outbreaks of animal disease demonstrate the potential threat from agroterrorism.

Food Security: "Farm to Fork"

There is another dimension to the threat from agroterrorism, namely that of food safety. In both developed and developing economies, there has recently been an increased focus on security surrounding the "farm to fork" cycle of the food industry—that is, the vulnerability of the food supply to deliberate contamination with toxins or pathogens. Such an attack could occur at the locations where crops or animals are first raised, at the midpoint processing facility, or even on the grocery shelves and at other points of sale. So far, the deliberate poisoning of food or beverages in modern societies has largely been a phenomenon reserved for criminal or malicious activity, and not organized warfare or terrorism. During the late 1990s, in China, a substantial number of cases occurred in which jealousy or hatred led individuals to contaminate food or beverages with rat poison, including the acutely toxic rodenticide tetramine (tetramethylene disulfotetramine). Mass poisonings have sometimes resulted, including a 2002 incident in which 40 people died and 300 others were seriously poisoned with tetramine.

Attacks on agriculture, however, could stem from purely financial motives. For example, after deliberately spreading a disease among cattle or corn, and thus causing a dramatic rise or fall in their prices on the world market, a malevolent actor might be able to take advantage by speculating on commodity futures.

Like the categories of pathogenic organisms that affect human beings, BW agents that could be used against agriculture include bacteria, viruses, fungi, and insects. Today, a number of possible BW agents have been recognized that could be used against crops or livestock animals (see tables A-7 and A-8 below). These lists, however, are by no means exhaustive.

Table A-7: Potential Anti-Crop BW agents

Bacterial diseases	*Bacterial agents*
Rice blight	*Xanthomonas oryzae*
Corn blight	*Pseudomonas alboprecipitans*
Viral diseases	*Viral agents*
Tobacco mosaic	Tobacco mosaic virus
Sugar-beet curly top	Curly top virus
Fungal diseases	*Fungal agents*
Late blight of potato	*Phytophthora infestans*
Rice blast	*Pyricularia oryzae*
Black stem rust of cereals	*Puccina graminis tritici*
Brown spot of rice	*Cochliobolus miyabeanus*

Table A-8: Potential Anti-Animal BW Agents

Rickettsial diseases (Bacteria)	*Rickettsial agents*
Heartwater of sheep and goats	*Cowdria ruminantium*
Viral diseases	*Viral agents*
Foot-and-mouth disease (FMD)	Foot-and-mouth disease (FMD) virus
Rinderpest (cattle plague)	Rinderpest virus
African swine fever	African swine fever virus
Aujeszky's disease	Herpes virus
Newcastle disease (poultry)	Newcastle virus
Avian influenza	Avian influenza virus
Fungal diseases	*Fungal agents*
Aspergillosis (poultry)	*Aspergillus fumigatus*

Targeting Crops and Animals: World War I and World War II

The devastating consequences of crop diseases were keenly felt by Germany during World War I, when large stores of potatoes were destroyed by potato blight (*Phytophthora infestans*), the same disease that accelerated the famines in Ireland during the mid-1800s. Some have even suggested that this potato famine contributed to Germany's capitulation and the end of the war. Also during World War I, Germany was probably the first to employ infectious agents (such as glanders, or *Burkholderia mallei*) against the Allies' horses and mules. These were small-scale sabotage operations, and it is unclear what the ultimate result was of these efforts.

Research programs among the Allies to defend against—as well as to offensively employ—crop and animal diseases began in earnest during World War II. In 1938, the British scientist J. B. S. Haldane proposed the notion that both Germany and England could be vulnerable to an attack on their respective agricultural industries by the highly destructive Colorado potato beetle. In 1939, French veterinary and BW experts even proposed dropping potato beetles on Germany's crops. None of these plans, as far as it is known, were ever carried out. In the early 1940s, the potential BW threat to Allied agricultural targets, as well as possible weaknesses in Axis food supplies, led to further research into a number of pathogens that could cause disease in crops and domesticated animals. Beginning with a recommendation by U.S. governmental experts in March 1942, a number of plant and animal pathogens were considered as possible biological weapons for use by the United States (see table A-9).

Anti-Livestock Agents (World War II)

Throughout the war years, animal diseases were very much a security concern for the Allies, as well as being potential weapons to be used against the Axis powers. During World War II, as far as U.S. intelligence was concerned, rinderpest (cattle plague) was one of the most threatening of the animal pathogens, because it was largely unknown in the Western Hemisphere at the time. Falling into the same group of viruses (morbillivirus) as human measles and distemper virus in dogs, rinderpest only infects animals (primarily cattle). The virus can be transmitted via contact with infected material, especially animal urine, as well as by airborne droplets. Rinderpest is so deadly and spreads so fast that—as in the case of FMD—the usual method of control is simply to destroy infected animals. In a joint American and Canadian project conducted at Grosse Ile on the St. Lawrence River, studies were led into developing large amounts of rinderpest vaccine against a possible BW attack by Germany against Allied agriculture. Allied military scientists also studied the foot-and-mouth virus during World War II.

Table A-9: World War II BW Research in Anti-Crop and Anti-Animal Pathogens (United States and Canada)

Project	*Code*	*Location*
Anti-crop agent		
Blight of potatoes	LO	Main Agricultural Experiment Station, Orono, Maine
Rice diseases	IR, E	Texas Sub-Station No. 4, Beaumont, Texas
Southern blight	C	Bureau of Plant Industry, Beltsville, Maryland
Anti-animal agents		
Fowl plague	OE	Harvard University
Foot-and-mouth disease	OO	Joint War Research Service–USDA Committee
Rinderpest	GIR-1	War Disease Control Station, Quebec, Canada

The most concerted Allied military program to attack Germany's agriculture, however, was dubbed Operation Vegetarian, in which Great Britain undertook to kill Germany's supply of domestic livestock. In 1943, an English soap factory molded some 5 million cakes impregnated with a slurry of anthrax (*Bacillus anthracis*) spores, which were designed to attract grazing cattle, horses, and sheep. Upon consumption, the anthrax bacteria would then cause a gastrointestinal form of the disease. (Although the primary goal was to destroy an important food source, this project also had the potential to cause human anthrax cases as well, via secondary infection.) The original plans required at least 1,250 planes to fly across Germany, each aircraft dropping about 10 boxes of the anthrax cakes per sortie. Ultimately, however, the plan to attack Germany's livestock with anthrax-laden cakes never materialized, and 30 years later, the last of the remaining cakes were destroyed.

Anti-Crop Agents

In 1943, Dr. E. C. Tullis at the Beaumont, Texas, facility noted that Japanese rice varieties grown in Arkansas were often subject to a fungal disease called rice blast (also known as rotten neck or Pyricularia blight), caused by *Pyricularia oryzae.* This fungal organism—along with another, brown spot of rice caused by *Helminthosporium oryzae* (*Cochliobolus miyabeanus,* code letter E), was researched for its possible use on Japanese rice fields. Rice blast is a severe threat to rice crops, and an outbreak of it was partly responsible for the 1942–1943 Bengal famine that led to the deaths of more than 2 million people. Its fungal spores are now found in the Western Hemisphere as well as Africa and Asia. During World War II, the United States investigated this disease as a potential weapon (code IR), but found that the conidia spores—the means by which the fungal agent reproduces and spreads from plant to plant—did not survive well in warm weather conditions. It was therefore not viewed as having much potential. By end of World War II, such research with fungal agents was largely inconclusive. The development of effective growth regulators for herbicidal applications—primarily the chemical herbicide 2,4-D—replaced schemes that would have used biological agents to destroy crops during the war. (Another mitigating factor against targeting rice crops was concern about the imminent military occupation of Japan and about the future source of food for the Japanese population.)

The Allies also observed at this time that Germany was economically dependent on potatoes. The United States conducted research into Southern blight (*Sclerotium rolfsii,* code C), a fungus that appeared to have potential as a BW weapon. By war's end, however, it was found to have little efficacy against resistant Japanese crops and was not pursued any further. Another fungus (*Phytophthora infestans*), the cause of potato blight that had destroyed Irish and German potato crops throughout the prior century, was known to be a potentially powerful BW agent. But this fungus was difficult to store, and a method of devising its large-scale production remained elusive. One method of delivery devised for potato blight involved the use of navy beans and specially made pellets. Again, these means of warfare were never used.

Cold War Activity

During the first half of the Cold War (1950–1969), work continued with anticrop agents in the U.S. offensive biological weapons program. Having revived earlier work with agents such as *Sclerotium rolfsii* (the cause of Southern blight or Sclerotium rot), the U.S. military later stockpiled some 30 tons of *Puccina graminis tritici* fungal spores (black stem rust). At that time, the United States considered the Chinese rice plantations and the extensive wheat fields in the Soviet Union (Ukraine) as potential targets. Early prototypes of delivery systems used feathers that were to be dropped in 500-pound propaganda leaflet bombs. These were judged by American bioweaponeers to "carry a sufficient number of spores to initiate a cereal rust epidemic" (Rogers, Whitby, and Dando, pp. 73–74). The former Soviet Union also led a significant research and development program into agricultural BW agents, many of these being similar to those studied in the West. The full extent, however, of Soviet and Russian work in offensive agricultural BW is still unknown. All U.S. work regarding the use of BW agents against crops and animals was halted in 1969 with President Richard Nixon's announcement forbidding further offensive biological weapons research.

Charges against the United States of using agricultural warfare continued throughout the Cold War, however. These included allegations by Fidel Castro's government in Cuba that the United States was deliberately disseminating an aggressive, fruit-burrowing insect (*Thrips palmi*) against Cuba's citrus crops. East Germany often accused the West of using Colorado potato beetles (the so-called *Ami-Kafer*) against Soviet bloc countries. Even in the late 1990s, the Russian BW expert General Valentin Yevstigneyev suggested that the United States was responsible for past beetle infestations in the former Soviet Union. These and similar charges were never substantiated.

During the 1980s, the Iraqi bioweapons program also conducted investigations into the use of anti-crop agents, including *Tilletia* fungus. Recognized as a serious disease in wheat since the 1700s (then described by the English agronomist Jethro Tull), *Tilletia* grows in the kernel of grains and develops into a "dirty" black center that completely devours the food portion of the plant. This wheat cover smut, or bunt of wheat, continues to devastate field grains throughout the world. In their work with fungi, Iraqi BW scientists tested wheat cover smut (*Tilletia* spp.) fungal spores in field trials, in combination with aflatoxin derived from *Aspergillus flavus.* During their experiments, Iraqi BW scientists used fine-powdered silica as a carrier for dry dissemination of a mixture of aflatoxin and wheat smut fungi. This could have served as a means to attack the food supply of Iraq's neighbor Iran, or perhaps Iraq's Kurdish populations to the north. It is noteworthy that Iraqi scientists used silica to distribute the agent in fine particulates, an indicator of a rather sophisticated BW program. In other areas, Iraq apparently worked with camel pox, a close relative to human smallpox (*Variola major*). The ultimate goals of this research are unclear. It is possible that Iraqi BW scientists were looking to employ antianimal attacks against an erstwhile enemy (e.g., Iran), or perhaps were looking for a surrogate for smallpox to use against human targets.

Although vaccines are available for a number of animal diseases, such as FMD, rinderpest, and *peste des petits ruminants* (e.g., "goat plague"), for various reasons these are not normally used in the developed world for prophylactic purposes, due to unit costs of the vaccine and the demands of regulated livestock markets. Furthermore, as with human viral diseases, effective chemotherapeutic treatments are lacking. Viruses also happen to be the cause of the most worrying of animal diseases—FMD, Newcastle, highly pathogenic avian influenza, etc. As a consequence, the primary defenses against agroterrorism are early detection of disease outbreaks, the separation of diseased animals (usually by culling) from healthy ones, and vaccinating a ring around the affected populations to stop the outbreak. In the United States, the primary defense against exotic and otherwise devastating diseases in plants and animals is the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS). The research and development of diagnostic, surveillance, and detection techniques are conducted at the Foreign Animal Disease Diagnostic Laboratory at Plum Island Animal Disease Center in New York. To develop an advanced warning capability, the USDA also has established its own intelligence units to analyze and predict future animal disease outbreaks.

—Eric A. Croddy

See also: Anthrax; Foot-and-Mouth Disease Virus; Glanders; Iran-Iraq War; Newcastle Disease; World War I; World War II: Biological Weapons

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AL-QAEDA

Al-Qaeda (Arabic for *base* or *foundation*) is the Islamic terrorist organization responsible for the September 11, 2001, attacks on the United States. The history of al-Qaeda is closely tied to the life of its leader, Osama bin Laden, and is mostly shaped by his experiences as part of the Arab *mujahideen* (holy warriors) in Afghanistan in the 1980s and his role as a Saudi political dissident.

In the early 1980s, the Saudi government supported the *mujahideen* resistance against the Soviet Union's invasion of Afghanistan, recruiting and sending Arab men from Saudi Arabia and other countries to fight in the name of Islam. At that time, bin Laden, with the help of the Saudi government, established the Islamic Salvation Foundation with the same purpose. After the withdrawal of the Soviet Union from Afghanistan—which was seen by the *mujahideen* as a victory for Islam produced by their efforts—many of these volunteer soldiers returned to their native Saudi Arabia, only to be disaffected and alienated from a government that they felt no longer appreciated them or upheld the values of Islam. Sharing this sentiment, bin Laden became a key player in the founding of a dissident organization known as the Advice and Reform Council.

Meanwhile, bin Laden was also active in south Asia. The World Muslim League and the Muslim Brotherhood organizations in Peshawar, Pakistan, led by Abdullah Azam, served as the center for the Arab *mujahideen* that remained in the vicinity. After Azam's assassination in 1989, bin Laden took over these organizations, forming them into al-Qaeda with the goal of developing a broad-based alliance among former Arab *mujahideen.*

Al-Qaeda's ideology is based on the Wahhabi branch of Sunni Islam, which demands the strict application of Islam to every aspect of political and social life. Additionally, al-Qaeda has elevated the concept of *jihad* (holy war) to a position of central importance in its interpretation of Islam. Al-Qaeda defines *jihad* as a duty for all Muslims to fight against *kafir* (infidels or unbelievers). For al-Qaeda, unbelievers include all non-Muslims, as well as those Muslims it believes do not adequately uphold the teachings of Islam. The Saudi royal family is among the Muslims targeted for destruction.

Al-Qaeda has four main grievances. First, it claims that the Saudi royal family is corrupt and does not uphold its professed Wahhabi beliefs. Second, it opposes Saudi cooperation with and reliance on the United States. Third, it sees the U.S. military presence in Saudi Arabia since the end of the first Gulf War as an "occupation" of Islamic holy sites. Fourth, it opposes U.S. support for Israel. Not only is al-Qaeda geographically disparate; it is also ideologically diffuse. In different geographical locations, certain issues are given emphasis by local cells. In all cases, however, local conflicts between cells are seen in the broader context of *jihad* against unbelievers.

This ideology of *jihad,* combined with al-Qaeda's grievances against what it saw as insufferable American cultural influences, led bin Laden to declare *jihad* against the United States in 1998, even though, as a secular leader, bin Laden lacked the religious authority to issue this type of edict. The original *fatwa* specifically mentions the United States, but also includes its allies: "The ruling to kill the Americans and their allies—civilians and military—is an individual duty for every Muslim who can do it in any country in which it is possible to do it, in order to liberate the al-Aqsa Mosque and the holy mosque from their grip, and in order for their armies to move out of all the lands of Islam, defeated and unable to threaten any Muslim. This is in accordance with the words of Almighty God, 'and fight the pagans all together as they fight you all together,' and 'fight them until there is no more tumult or oppression, and there prevail justice and faith in God'" (quoted in Poonawalla, 2003, online). Even before

Seventeen sailors on the U.S.S. Cole *died in an al-Qaeda–sponsored suicide attack on October 12, 2000. (Reuters/Corbis)*

declaring *jihad* against the West, however, al-Qaeda was on the path to war. Al-Qaeda is believed to have been responsible for attacks against Americans worldwide: eighteen U.S. soldiers killed in Mogadishu, Somalia, in 1993; five U.S. soldiers killed in a Riyadh, Saudi Arabia, bomb attack in 1995; and nineteen U.S. military personnel killed in Dhahran, Saudi Arabia (Khobar Towers), in 1996. Among the perpetrators of the Khobar Towers bombing was Ibrahim Salih Mohammed Al-Yacoub, who was indicted in Virginia. (Suggestions made in 2003 implied that Iran also may have played a role in the Khobar Towers bombing.) Al-Qaeda is also suspected of being involved in the 1992 bombings in Aden, Yemen; the 1993 World Trade Center bombing; a 1994 plot to assassinate President Bill Clinton; and a 1995 plan to blow up a dozen U.S. jetliners over the Atlantic Ocean. More recently, al-Qaeda has been charged with perpetrating the U.S. embassy bombings in Kenya and Tanzania in 1998, as well as the attack on the U.S.S. *Cole* in 2001.

Since its formation, al-Qaeda has attempted to acquire or develop weapons of mass destruction, including nuclear, chemical, biological, and radiological weapons. In November 2001, U.S. forces in Afghanistan discovered the blueprints for a crude nuclear bomb in a house in Kabul. It has been reported that al-Qaeda has tried on numerous occasions to obtain uranium or other radioactive materials. Reports by both U.S. and British intelligence sources indicate that al-Qaeda was successful on at least one occasion. Under interrogation, a senior al-Qaeda official, Abu Zubayda, indicated that al-Qaeda had in fact constructed a radiological "dirty" bomb. British intelligence sources have confirmed this information, adding that the crude device was constructed in an al-Qaeda laboratory in the town of Herat, Afghanistan.

Al-Qaeda has also made attempts to develop chemical and biological weapons. Bin Laden has expressed his desire for the group to develop a CBW capability. Files recovered from al-Qaeda computers and equipment found in al-Qaeda laboratories in Afghanistan support bin Laden's statements and indicate that the group at one time had the capability to produce limited quantities of some CBW agents. For example, one lab near Kandahar was equipped to produce anthrax. Finally, in August 2002, the

Cable News Network (CNN) broadcast al-Qaeda–produced videotapes that it had obtained in Afghanistan that showed dogs being killed by clouds of unknown toxic chemicals. These were probably trials or demonstrations of hydrogen cyanide gas.

—*Sean Lawson*

See also: Al Shifa; Osama bin Laden; Terrorism with CBRN Weapons; World Trade Center Attack (1993)

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AL SHIFA

On August 20, 1998, in response to the U.S. embassy bombings in Kenya and Tanzania two weeks prior, the United States struck the Al Shifa Pharmaceutical Factory in Khartoum, Sudan, with twelve cruise missiles, destroying the factory, killing one person, and injuring ten. Al Shifa was located in an industrial area northeast of Khartoum. It consisted of four buildings, one for administration and three production buildings. Construction of the factory, funded by Bashir Hassan Bashir and Salem Baboud, began in 1992 and was completed in 1996. In March 1998, Bashir and Baboud sold the plant to Salaheldin Idris, a Sudanese-born Saudi businessman.

Al Shifa was the largest of six pharmaceutical factories in Sudan, employing approximately 300 people and providing 50 to 60 percent of the country's pharmaceutical needs. The factory produced veterinary medicines, as well as medicines for the treatment of malaria, diabetes, hypertension, ulcers, rheumatism, gonorrhea, and tuberculosis.

Prior to 1998, the United States had neither officially nor publicly identified the Sudan as a chemical weapons proliferation state of concern. There had been previous accusations leveled by the West, including the U.S. government, of CW activity in Sudan dating as far back as 1989, however, although few of these charges had appeared credible. Beginning in 1997, Human Rights Watch and various Sudanese opposition groups began to claim that three facilities within Sudan were involved in CW activities: Kubar, Kafuri, and Shegarra. All three were located near Khartoum. Neither Human Rights Watch nor the Sudanese opposition groups mentioned Al Shifa.

After the 1998 bombings of U.S. embassies in Africa, U.S. intelligence linked Al Shifa to Osama bin Laden, his global terrorist network, and his attempts to acquire WMD (*see* Osama bin Laden and Al-Qaeda). The United States alleged that the factory was a closed facility, guarded by elements of the Sudanese military, and that it did not produce any commercial pharmaceutical products. The United States claimed to have evidence indicating that Iraq was involved in CW activities at Al Shifa and that its new owner, Salaheldin Idris, was connected through the Egyptian Islamic Jihad organization to bin Laden. Finally, the cornerstone of U.S. allegations of CW activities at Al Shifa was a soil sample purported to show high levels of a VX nerve agent precursor chemical (O-ethyl methylphosphonothioic acid, also known as EMPTA). U.S. officials claimed that EMPTA had no legitimate commercial use and was therefore an indicator of illicit CW activities at the Al Shifa facility (*see* EMPTA).

Within days following the U.S. strike on Al Shifa, U.S. allegations regarding the plant came under serious scrutiny. Since the incident, the United States has been accused of acting hastily based on limited intelligence and without the participation of the full U.S. intelligence community. After the incident, U.S. documents apparently unknown to those who decided to strike Al Shifa, as well as eyewitness accounts from the factory, indicated that the factory did indeed produce commercial pharmaceutical products. Eyewitness reports from the factory before the strike also indicated that it was not closed, nor was it guarded by the Sudanese military. Furthermore, independent, unclassified reports were inconclusive as to the relationship between the factory's owner, Salaheldin Idris, and either Osama bin Laden or the Sudanese government. Finally, after the strike, spokespersons for the Organization for the Prohibition of Chemical Weapons (OPCW) announced that EMPTA is considered a dual-use chemical, with applications in the production of fungicide, pesticide, and antimicrobial agents.

Although the presence of EMPTA in the aforementioned soil sample is persuasive, it is still unclear whether Al Shifa had been involved with the manufacture of VX agent, whether at the time of the strike or perhaps several months earlier (*see* V-Agents).

—*Sean Lawson*

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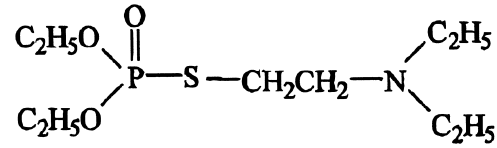
AMITON (VG)

Originally developed as a pesticide, amiton was among the first series of phosphonothiolate esters synthesized by Ranajit Ghosh, a chemist at British Imperial Chemical Industries, in the 1950s. Later, a commercial insecticide included amiton in an oxalate salt for civilian uses. Although not as toxic as other V-agent analogues, amiton (also known as Tetram; U.S. military code VG) had potential for use by the military as a nerve agent. A highly toxic organophosphate (OP), amiton has since been made obsolete due to safety concerns. Because of its highly toxic nature and its potential for use as a chemical warfare (CW) agent, it is listed as a Schedule 2 toxic compound in the Chemical Weapons Convention (CWC). The chemical structure of amiton is quite similar to that of VX nerve agent, the direct carbon-phosphorus bond being the significant chemical group separating VG from VX.

In mammals, the toxicity of amiton is significantly lower than that of VX. For example, tests on laboratory rats show the average lethal dose for oral administration of amiton to be 5 milligrams per kilogram of body weight. The lethal dose for VX, by comparison, is estimated at 12 micrograms for the same animal and route of exposure, or about 400 times more toxic than amiton. Still, amiton is relatively easy to manufacture, especially when compared to other nerve agents such as VX. Its chemical structure is also likely to provide a relative degree of persistency in terms of physical characteristics, and its moderate oil solubility makes VG capable of penetrating the skin. Therefore, considering its potency as a nerve poison, VG could be manufactured by state military programs trying to achieve a chemical weapons capability inexpensively, or perhaps by terrorist organizations looking for a simple method for producing a highly toxic OP compound.

Figure A-2: Amiton (VG)



—*Eric A. Croddy*

See also: Parathion (Methyl and Ethyl); V-Agents

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AMMONIUM NITRATE FUEL OIL (ANFO)

Ammonium nitrate fuel oil (ANFO) is a low-velocity (meaning the speed of expansion following a blast is less than higher-yield explosives such as TNT), pushing-type secondary explosive (see definition below) used primarily to move earth and rock. Because the materials involved in its production are readily available, it is easy for individuals in the agricultural industry to produce large volumes of ANFO without attracting attention.

In the 1650s a chemist by the name of J. R. Glauber prepared what he called "*Nitrum Flammans,*" now known as ammonium nitrate. He did not recognize its utility as a component in explosives. In the early nineteenth century, researchers Grindel and Robin looked to develop black powder—the classic explosive of the time until smokeless powder was introduced—using ammonium nitrate instead of potassium nitrate. The results of this excursion are unclear. In the early years of mass production and use of ammonium nitrate, numerous and sometimes disastrous incidents including explosions occurred. Still, its utility as an explosive went largely unnoticed until the twentieth century.

Texas City Disaster: 1947

A French cargo vessel, the S.S. *Grandcamp,* docked at Texas City on 16 April 1947, was carrying a supply of ammonium nitrate fertilizer. (The shipment was destined for use as fertilizer as part of the Marshall Plan for the reconstruction of war-ravaged Europe). When a fire accidentally broke out on the ship, subsequent attempts to douse the flames resulted in pressurized steam, and put the ammonium nitrate cargo under pressure. Meanwhile, black smoke issued from a bright orange flame, and local inhabitants decided to go outside to witness the spectacle. Despite the fact that ammonium nitrate was known to be a potentially hazardous oxidizer—known to react explosively with a variety of fuels such as oil and kerosene—none seemed to be aware of the danger.

At 9:12 A.M., the ammonium nitrate on the boat detonated. Someone immediately speculated that "the Russians" had dropped an atomic bomb on the city of 18,000 people. The event registered as far away as Oklahoma City (480 miles) on a seismograph. Creating a two-thousand-foot mushroom cloud—and an explosion that could be heard for 150 miles—it probably could have been mistaken for a nuclear device. Secondary fires erupted at the Monsanto Chemical Plant, while additional conflagrations spread to nearby petroleum refineries. Another blast occurred early the next morning at about 1 A.M., when another vessel carrying ammonium nitrate, the *High Flyer,* erupted in even more spectacular fashion. This time nearby oil depots were set ablaze, along with warehouses and a grain elevator. In all, at least 581 people died, and over 3,500 were injured. Over 30 percent of the residential homes in Texas City, or about 500, were seriously damaged, and two thousand people were subsequently made homeless. This horrific incident showed the obvious dangers of handling ammonium nitrate, while also highlighting its potential utility as an explosive.

Ammonium nitrate fuel oil was developed in the 1950s as a low-cost earth-moving charge to replace dynamite. The primary problem encountered in using this explosive is water ingress: ammonium nitrate readily absorbs water, which decreases its sensitivity and slows its detonation. The introduction of fuel oil helps to dissipate this effect, and it promotes uniform caking of the material, leading to more efficient combustion.

Oklahoma City Bombing, 1995

The most horrific domestic use of ANFO as a weapon has been the bombing of the Murrah Federal Building in Oklahoma City in 1995. In seeking out an explosive for his purposes, Timothy McVeigh selected ANFO for several reasons. The primary components were easily acquired in bulk in the agricultural communities of the American Midwest without drawing any attention from law enforcement, and the materials for bomb construction were inexpensive. McVeigh created a very large device because he believed that, due to the lower yield of ANFO in relation to other high explosives, a large container would be needed to construct a very powerful weapon. McVeigh probably did not realize that the compressed air shock wave produced by slower-detonating materials (e.g., ANFO) is highly effective against rigid building components.

McVeigh rented a delivery truck, filled it with ANFO in 55-gallon drums, added booster charges, and parked it at the curb next to the Murrah Building. The tricky part of the operation involved setting all the detonators to go off simultaneously. Due to the comparatively low sensitivity of ANFO, a single detonation might have pushed most of the AFNO harmlessly away from the primary blast. Ultimately, McVeigh succeeded in creating a simultaneous detonation of the AFNO, which produced extensive damage to the Federal Building and hundreds of casualties. The federal courthouse across the street was severely damaged, and glass was broken in the windows of many downtown buildings. Injuries in other buildings from the shock wave and flying glass added to the numbers of victims.

The Murrah Building tragedy, coming just weeks after the Aum Shinrikyo attack on the Tokyo subway system, led the U.S. Congress to take action to help the nation's largest cities to prepare to respond to terrorist attacks. The Nunn-Lugar-Domenici amendment to the 1997 Department of Defense Appropriation Bill provided funding for the Department of Defense, Department of Health and Human Services, Department of Justice, Federal Emergency Management Agency, Environmental Protection Agency, and Department of Energy to join the nation's 122 largest cities in the Domestic Preparedness Program.

Technical Aspects

Ammonium nitrate fuel oil is a secondary explosive (the more powerful of the two types; see Explosives) and may require a booster to detonate it, depending on its water content. ANFO produces shock waves that cause indirect shattering or compression of its target (as compared to some other explosives, which work by direct shattering or "cutting" through the target material). Ammonium nitrate has 42 percent of the efficiency of TNT. Thus, it detonates at a velocity of only 8,900 feet per second as compared to TNT, which detonates at 22,600 feet per second. Given that the prime ingredient of ANFO is ammonium nitrate, most high-grade fertilizer is acceptable as a component. A minimum of 32 percent of the fertilizer, by weight, must be ammonium nitrate, and the material must be as dry as possible. The secondary ingredient, fuel oil, can be either diesel fuel oil or a 1 to 1 mixture of motor oil and gasoline. The less ammonium nitrate that is present in the fertilizer, the more fuel oil is needed to offset the moisture.

As mentioned previously, ANFO is used in industry as an earth- and rock-moving charge for mining and earthworks. In commercial use, ANFO is mixed at the site, and only as needed. The American military also uses ammonium nitrate for earthmoving and as a cratering charge to destroy buildings, fortifications, and bridge abutments. The military munition is a 40-pound device containing 30 pounds of ammonium nitrate and 10 pounds of TNT-based explosive as the booster.

The simplicity of ANFO and availability of materials have made it popular among various terrorist groups for decades. In Europe, ANFO explosives have been used so widely that government regulations require AN to be produced in prills too large to be able to be used in explosives. Vehicle-borne ANFO bombs became a standard item, particularly with the Provisional Irish Republican Army. Over time, these vehicle bombs grew in size to include trucks.

Ammonium nitrate is used every day by law-abiding individuals in their legal pursuits. Following the Oklahoma City bombing, increased law enforcement awareness and legislation has been pursued surrounding fertilizers with heavy ammonium nitrate concentrations. Due to the huge volume of this material used in agricultural and commercial operations, it is highly unlikely that complete control over its sale and movement will ever be established. Policing is left largely to the retail fertilizer industry, and that policing relies on making note of individuals seeking this material based on its composition and dryness, as well as keeping track of the location, volume, and method of payment for each purchase.

—Dan Goodrich and Eric A. Croddy

See also: High Explosives; Oklahoma City Bombing

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ANTHRAX

Anthrax is an acute infectious disease and one of the most feared BW agents, due, in part, to its high fatality rate. Anthrax is classified by the Centers for Disease Control (CDC) as a category A bioterror threat because it can be easily disseminated, it can result in high mortality rates, it has the potential for a major public health impact, it can cause public panic and social disruption, and it requires special action for public health preparedness. Although numerous other category A threats are deadly, anthrax in particular elicits a sense of fear since September 2001, when it was deliberately spread through the U.S. postal system. This attack caused twenty-two cases of infection and five deaths. This act of bioterrorism caused the first death from inhalatory anthrax since 1976.

Background

Anthrax was the first disease for which a microbial origin was definitively established (by Robert Koch in 1876). *Bacillus anthracis,* the causative agent of anthrax, is a disease of grazing mammals (sheep, cattle, etc.) that can be transmitted to humans (zoonose), although this is uncommon nowadays. This large, gram-positive (absorbs the color stain), nonmotile bacterium occurs in two distinct forms: the vegetative, rod-shaped form, which is the actively growing and replicating phase, and the spore form, which is the dormant, resistant phase. When conditions become unfavorable for this microbe's survival (e.g., lack of nutrients), it forms a rigid outer shell through a process called sporulation. These spores are oval, colorless, odorless, tasteless, microscopic, and hardy, capable of surviving in the soil for years.

An envelope tested positive for anthrax spores at the Daily Jang *newspaper offices in Pakistan (November 2, 2001). (Reuters/Corbis)*

Although humans are more resistant to anthrax than grazing mammals (such as sheep), *B. anthracis* can cause three distinct diseases in humans depending on the route of exposure. The first and deadliest form, inhalation anthrax, is contracted by inhaling the spores and is the only form that poses a serious BW threat. Inhalation anthrax is characterized by flulike symptoms including a sore throat, fever, muscle aches, and malaise. After this acute phase, there is sometimes a brief improvement, followed by respiratory failure and shock, with meningitis also frequently developing. Chest X-rays usually show a characteristic widening of the mediastinum—tissues surrounding the lymph in the chest—due to hemorrhaging of local lymph nodes. (For more information on how anthrax spores cause disease in the body, see Biological Warfare.) Case-fatality estimates are extremely high even with treatment, and close to 100 percent of those infected with inhalation anthrax will die without treatment. In 2001, five of eleven inhalatory anthrax cases ended in death. Improved treatment resulted in a fatality rate lower than previously estimated, however.

The second and most common form of anthrax, making up some 95 percent of all cases, is cutaneous anthrax. This type usually occurs after contact with infected animals or animal products and is usually related to occupational exposure (anthrax was once called wool sorter's disease). The bacterium gains entry through a break in the skin, and infection begins as a papule, progressing into an ulcer with a central black necrotic area. Other symptoms include fever, malaise, headache, and regional lymph node swelling. The term *anthrax* is derived from the Greek word for coal, *anthrakis,* because of the characteristic black skin lesions. Fatality of this type is less than 1 percent with treatment and between 5 and 20 percent without.

The third form, gastrointestinal anthrax, is rare (no confirmed cases in the United States), usually follows consumption of contaminated meat, and is characterized by severe gastrointestinal symptoms. The fatality rate is 25–60 percent even with treatment.

Symptoms can appear within 7 days of contact for all three disease types but can take up to 60 days to appear for inhalatory anthrax.

Diagnosis and Treatment

There is no rapid screening test for early inhalatory anthrax diagnosis, and because many illnesses begin with flulike symptoms, the disease is difficult to spot. Diagnosis is made by isolating and culturing *B. anthracis* from the blood, skin lesions, or respiratory secretions, measuring serum antianthrax antibodies, or DNA testing. Results are usually obtained within 24 hours.

Upon infection, *B. anthracis* multiply fast, rapidly producing toxins and spreading from the lungs into the bloodstream, resulting in death within days. Once flulike symptoms appear, the bacteria have already produced copious amounts of toxins, against which antibiotics are useless. Therefore, once a victim is symptomatic, anthrax has nearly always progressed too far for treatment. Anthrax is usually susceptible to the antibiotics amoxicillin or doxycycline, but in a BW attack, antibiotic resistance is possible due to the potential of genetic manipulation by the weapon designer; therefore, alternate antibiotics such as ciprofloxacin ("Cipro") may need to be used. Before the 2001 attacks, ciprofloxacin was considered the first line of defense for anthrax. To avoid individuals' developing resistance to ciprofloxacin, however, the CDC now recommends initially considering other antibiotics that are equally effective (in the absence of resistance), are less expensive, and have fewer side effects. Treatment is continued for 60 days due to the possibility of delayed spore germination.

History

In 1876, Robert Koch first described *B. anthracis* as the cause of anthrax, which helped lead to the first animal anthrax vaccine, developed by Louis Pasteur in 1881. Max Sterne developed an improved attenuated (mutated) live animal vaccine in the 1930s, which is still used today.

Human vaccines (live attenuated) were developed in the Soviet Union in 1940 and in the United States and Great Britain (bacteria-free filtrates from attenuated strains) in the 1950s. An improved version called Anthrax Vaccine Adsorbed (AVA) is produced by BioPort and was approved in 1970 by the U.S. Food and Drug Administration for those at risk. The government intends to make AVA more widely available once further requirements are met. The immunization involves six shots over a period of 18 months, with annual boosters.

During a quest for improved vaccines, the U.S. military researchers at Fort Detrick, Maryland, requested a strain of anthrax from the Department of Agriculture. They received a particularly virulent strain from Texas A&M University in 1981 (but mistakenly attributed it to the USDA laboratory in Ames, Iowa) and have since referred to that strain as the Ames strain. During the bioterrorist incidents in 2001, this strain was the same used in the anthrax letters mailed in the United States.

Anthrax has played a long and devastating role in human history. An epidemic in seventeenth-century Europe caused 60,000 deaths. Today, only approximately 2,000 human cases are reported worldwide annually; these are mostly the cutaneous type and occur mostly in developing countries (rarely do any cases occur in the United States). The largest international outbreak in modern times has been in Zimbabwe (1979–1980), with more than 10,000 people infected and over 180 deaths. Nearly all of these were of the cutaneous form of anthrax, although some cases of inhalational and gastrointestinal anthrax cannot be ruled out.

Before the advent of safer handling processes, vaccines, and improved veterinary management of domesticated animals, "wool sorter's disease" was a relatively common occupational hazard in wool-related textile mills, especially during the eighteenth-century Industrial Revolution. This deadly job-related illness was caused by inhaled anthrax spores liberated from newly spun wool, causing not only cutaneous but also the more deadly inhalational anthrax. This hazard became much less common in the twentieth century, however, and is nearly unheard of today. According to the Center for Nonproliferation Studies, between 1900 and 1978 only eighteen cases of inhalatory anthrax were reported in the United States. Two of those occurred among researchers working in a medical laboratory.

One landmark case occurred in 1957 in Manchester, New Hampshire, when nine workers at a goat hair processing plant became infected after handling a contaminated shipment of skins from Pakistan. Four of the five workers who contracted inhalation anthrax died. Interestingly, the individuals who died were not vaccinated against anthrax.

Although the numbers of actual cases were too small for a proper scientific conclusion, one of the lessons learned from this incident is that inoculating workers with anthrax vaccine probably protected them from the inhalational form of the disease.

Bioterrorism

Evidence suggests that during World War I, Germany used covert operations with anthrax-infected animal feed and livestock against the Allied forces and injected anthrax into American livestock. Japan also conducted BW research in occupied Manchuria, China from 1932 to 1945. Approximately 3,000 scientists worked to weaponize anthrax and other disease agents. The Japanese research program, designated Unit 731, tested anthrax bombs on humans. Anthrax-contaminated food was dropped on Chinese cities, and anthrax-filled chocolates were given to children in Nanking, China. By the end of World War II, the Japanese BW program had stockpiled nearly 900 pounds of anthrax, to be used in specially designed fragmentation bombs. After the war, Unit 731 leaders were granted immunity from war crimes prosecution in return for the disclosure of their research.

The United States and Great Britain weaponized anthrax during World War II as a potential retaliatory weapon against a German BW attack. In 1942, the United States formed the War Research Service. About 5,000 anthrax-filled bombs were produced at Camp Detrick, Maryland (now Fort Detrick). The British tested anthrax bombs on Gruinard Island off the northwest coast of Scotland (1942–1943). They also stockpiled anthrax-laced cattle cakes.

President Richard Nixon terminated the U.S. offensive BW program in 1969, and the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) was established to develop BW defenses. The United States, Soviet Union, Iraq, and many other countries later signed the 1972 Biological Weapons Convention (BWC).

Despite their treaty obligations, however, the Soviets maintained a huge BW program until at least 1992. They built a production facility for anthrax bombs at Stepnogorsk (located in Kazakhstan). On April 2, 1979, Military Compound 19 (the Microbiology and Virology Institute) in Sverdlovsk (now Yekaterinburg) accidentally released anthrax spores into the atmosphere, causing the largest inhalatory anthrax epidemic in this century. The official Soviet statistics reported years later that 96 people were infected, resulting in 64 deaths. Others have estimated that between 68 and 600 deaths were caused by this accidental release of anthrax. Soviet officials attributed the outbreak to contaminated meat, but in 1992, Russian President Boris Yeltsin acknowledged that military-related anthrax study was conducted at the research institute. In addition, Soviet BW testing was conducted on Vozrozhdeniye Island in the Aral Sea in the 1970s and 1980s.

In 1997, Russian scientists reported that they had created a genetically engineered vaccine-resistant strain that caused anthrax in laboratory animals, but have denied other researchers access to their discovery. The Pentagon announced plans to copy the Russian experiment to test the efficacy of the current U.S. vaccine. Currently, the United States and Russia are in discussions over how to obtain this strain for additional testing.

In 1985, Iraq began an offensive BW program and, after the Persian Gulf War, Iraq admitted to the UN Special Commission (UNSCOM) that it had amassed 6,000 liters of anthrax, deployed 5 Scud missiles and several 122-mm rockets filled with anthrax, and produced 50 bombs filled with anthrax spores. They also had spray tanks fitted to aircraft that could distribute biological agents over a specific target. These “death-drones” were targeted during Desert Fox, the joint U.S./U.K. air attack on Iraqi BW installations in December 1998.

Aum Shinrikyo, the doomsday cult behind the deadly sarin gas attack in Tokyo’s subway in 1995, tried twice to disperse aerosol anthrax from the roof of Aum Shinrikyo’s office building in Tokyo in 1993. The attacks failed, partly because they used the nontoxic vaccine strain (Sterne).

The threat from state-sponsored programs using anthrax as a biological weapon is difficult to assess, as many countries are capable of producing and delivering this weapon. But, as the case below demonstrates, even smaller groups or individuals are capable of causing great harm and anxiety using anthrax as a weapon of terror.

The 2001 U.S. Anthrax Attack

Shortly after the terrorist attacks on the World Trade Center and Pentagon on September 11, 2001, four anthrax-laced letters were mailed from Trenton, New Jersey, to the *New York Post,* the NBC Television studios in New York, and Senators Tom Daschle and Patrick Leahy. A fifth letter (sent to American Media, Inc.) was apparently discarded after being opened. An estimated total of 10 grams of spores were contained in the letters, leading to 22 anthrax cases in 4 states (New York, New Jersey, Florida, and Connecticut) and the District of Columbia. The CDC confirmed that eleven victims were infected from inhalatory anthrax (five of these victims died), and eleven others suffered from cutaneous anthrax.

Genetic analyses of the anthrax in the letters matched perfectly with Fort Detrick's 1980 Ames strain. Therefore, the source of anthrax was probably the U.S. biological warfare program, which had officially destroyed its stores of weaponized anthrax in 1969. Given the origin of the anthrax and the warnings contained in the letters ("We have this anthrax. You die now. Are you afraid?"), the perpetrator's motive was probably not to kill large numbers of people but to raise public fear. Although the death toll was relatively low, the strikes crippled business, government, and postal services and strained the public health system.

Table A-10: Chronology of Events in 2001 U.S. Anthrax Attacks

9/18, Trenton, NJ	Anthrax letters mailed to NBC, *NY Post*, and probably to the *National Enquirer* (AMI).
9/19–25, NYC	NBC received and opened anthrax letter; not recognized as dangerous and not reported by media.
9/22, NYC	First suspected case of cutaneous anthrax, 30-year-old woman, *NY Post* employee.
10/5, Boca Raton, FL	First death from inhalatory anthrax (Stevens, 63, photo editor, American Media, Inc. [AMI]).
10/8, Boca Raton, FL	Second AMI person sick (Blanco, 73, mailroom worker); inhalatory anthrax later confirmed; FBI takes over investigation.
10/9, Trenton, NJ	Anthrax letters mailed to Daschle and Leahy.
10/10, Boca Raton, FL	Third AMI worker (mailroom worker) tests positive for anthrax. Anthrax strain appears to be Ames.
10/12, NYC	Cutaneous anthrax case reported at NBC (Tom Brokaw's assistant).
10/13, NYC	NBC anthrax letter first reported.
10/13, Boca Raton, FL	At least 6 workers at AMI have tested positive for anthrax.
10/5, Washington, DC	Daschle's office opens anthrax letter.
10/16, Trenton, NJ	Two postal workers report symptoms; by 10/20 are diagnosed with inhalatory anthrax.
10/19, NYC	Anthrax letter found unopened in mailroom.
10/20	First mention that source is probably domestic.
10/21, Washington, DC	Several DC postal workers may have anthrax. Second anthrax death (Morris, 55, postal worker).
10/22, Washington, DC	Third anthrax death (Curseen, 47, postal worker).
10/31, NYC	Fourth death (Nguyen, 61, hospital worker). Presumed cross-contamination of mail.
11/6, CT	Fifth anthrax death (Lundgren, 94). Presumed cross-contamination of mail.

Technical Aspects

To reach the lower lung and be most effective, anthrax spores need to be delivered in particles 1–10 microns (µm). Particles of much larger size are more apt to stick in upper airways and the throat, where a higher dose is required to cause infection. As the spores measure approximately 1 um, a powder of individual spores is best, but natural surface charges cause spores to clump and to stick to surfaces, making aerosolization difficult.

Anthrax "weaponization" is the purification, separation, and concentration of spores into fine particles capable of aerosolization (i.e., having a neutralized surface charge), with a very narrow size range (1.5–3 microns in diameter) and an extraordinary concentration (one trillion spores per gram) and purity. The anthrax spores contained in the 2001 senators' letters were uniformly tiny and had no surface charge, and were therefore weaponized.

Inhalatory anthrax is the most likely form of disease to follow a BW attack and will likely involve the aerosolized delivery of spores. An aerosol spray of spores would leave little to no indication of dispersal until a resulting, sudden outbreak of inhalatory anthrax occurred. It has been estimated that a release of 100 kilograms of spores upwind of Washington, D.C., would result in up to 3 million deaths (WHO Expert Committee, 1970).

Current anthrax defensive research involves improving rapid diagnostic methods and prophylactic and advanced therapeutic regimens. Some new treatment methods might include specially prepared antibodies, and substances designed to block the anthrax toxin at the cellular level.

—*Beverly Rider*

See also: Aerosol; Bioterrorism; Sverdlovsk Anthrax Accident

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ARALSK SMALLPOX OUTBREAK

Although smallpox has been eradicated for more than 25 years and was nearing extinction as a disease in many parts of the world, an outbreak of smallpox occurred in 1971 in Aralsk, Kazahkstan (at the time still part of the Soviet Union). Alan P. Zelicoff, M.D., a researcher at the U.S. Department of Energy's Sandia National Laboratories, has reported (2002, Tucker and Zilinskas) that the origin of the smallpox outbreak in Aralsk was most likely the result of Soviet biological weapons testing of *Variola major* virus, the causative agent of smallpox. Other experts are more reserved, and some wholeheartedly disagree with Zelicoff. In the event the fact that there was a smallpox outbreak at Aralsk or that the Soviet Union had weaponized the smallpox virus was unknown until the 1990s.

From about 1936 to 1992, Vozrozhdeniye (Renaissance) Island, located between Kazakhstan and Uzbekistan, was the site of open-air field testing of BW agents developed by the Soviet military. At various times, Soviet military scientists tested the BW agents *Francisella tularensis* (tularemia), *Yersinia pestis* (bubonic plague), *Bacillus anthracis,* and smallpox virus (*Variola major*) at the Vozrozhdeniye Island facility. Vozrozhdeniye Island lies on the Aral Sea, as does the city of Aralsk, then a city with a population of about 50,000. In fall 1971, an outbreak of smallpox infected ten people, three of whom died. Officially, the Soviet Union had eradicated smallpox as a disease on its extended territory by 1940. (Cases of smallpox had been reported by the Soviet Union in 1961, but apparently these infections were brought into the country by travelers.)

In 1952, concerned that the United States could use offensive BW against the Soviet Union, the Soviet military restarted a field testing program for biological weapons at Vozrozhdeniye Island. Two years later, the Soviet military established a center for smallpox research at Zagorsk (now Sergiyev Posad). At first, the mission of the Scientific Research Institute of Medicine (now called the Virology Center of the Scientific Research Institute of Microbiology) at Zagorsk was to develop smallpox vaccine, but by the 1960s, intense efforts to weaponize BW agents, including *Variola* virus, were underway.

On about July 15, 1971, a Soviet research boat began an extended voyage in and around the Aral Sea, starting from Aralsk. It made about twenty-five stops at various research stations before returning home. On board were a number of scientific researchers and staff, including an expert on fisheries (ichthyologist). The job of this individual, who would turn out to be smallpox patient number 1, was to cast nets and collect fish and plant specimens. Because her duties required her to be outside on the boat, it is possible that she was more vulnerable to exposure to smallpox from Soviet open-air testing. On August 6, the researcher developed symptoms that would later be diagnosed as smallpox, but only after she had infected nine more people.

If indeed the researcher had acquired her infection as a result of open-air testing of *Variola major* virus, it was mostly a function of Soviet military secrecy that prevented early diagnosis of smallpox among the victims of Aralsk. Because the Soviet Union had officially eradicated smallpox 30 years prior to the incident, attending physicians first ascribed the illness to various causes and did not initially consider smallpox as the source. Eventually, three of the ten people who became ill with smallpox died. The three who died had not been vaccinated against the disease and developed the most serious form of hemorrhagic smallpox. Thirty years later, during an interview with the Russian press in November 2001, Dr. Pyotr Burgasov, former chief hygiene medical officer for the Soviet Union, said that a female researcher on a research boat that had neared Vozrozhdeniye Island had been infected with smallpox and had subsequently spread the disease to others in Aralsk. Dr. Burgasov claimed that the outbreak was caused by the open-air test release of about 400 grams of smallpox virus. Because Dr. Burgasov had previously been known to deny the existence of a Soviet BW program (particularly concerning the Sverdlovsk anthrax outbreak in 1979), his anecdote is especially important to support the theory that the smallpox outbreak in 1971 indeed was caused by Soviet BW testing at Vozrozhdeniye Island.

Although the exact cause of the Aralsk smallpox outbreak has not been officially determined by any government—including that of Russia—the preponderance of evidence leads to the conclusion that an accidental exposure from open air testing on Vozrozhdeniye Island was the source of the infection.

—Eric A. Croddy

See also: Biopreparat; Russia: Chemical and Biological Weapons Programs; Smallpox

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ARBUSOV REACTION

Two giants in the development of organophosphorus chemistry—Carl Arnold August Michaelis (d. 1916) and Aleksandr Ermingeldovich Arbuzov (d. 1968)—are often cited in the scientific literature as having described a chemical reaction that is typical in nerve agent synthesis. Both Michaelis and Arbuzov conducted groundbreaking research in the synthesis and description of countless phosphorus-containing substances. The German chemist Michaelis was in many ways the founder of this particular subset of chemistry, and Arbuzov (as well as his son and daughter) continued this work. Today, there still stands the A. E. Arbuzov Institute of Organic and Physical Chemistry of the Kazan Scientific Centre of the Russian Academy of Sciences (Volga region).

The Arbuzov (or Michaelis-Arbuzov) reaction occurs when a carbon atom or chain (alkylation) is combined to a trivalent phosphoric ester, that is, an acidic phosphate surrounded by three alcohol groups. The carbon-phosphorus bond—a key feature of the more toxic nerve agents (e.g., Sarin, VX, etc.)—can then be produced by an alkyl halide (a carbon group with a halogen), such as methyl iodide. According to Japanese sources, the terrorist cult Aum Shinrikyo used an analogous route of synthesis when producing sarin nerve agent. Aum operatives disseminated sarin on at least three occasions, resulting in the deaths of seven people in 1994 (Matsumoto City), and in twelve deaths and more than 1,000 people being injured during an attack on the Tokyo subway in 1995.

Curiously, neither Michaelis nor Arbuzov themselves produced organophosphate esters that were exceptionally toxic to mammals—or if they did so, these went unreported. This would have to wait for German chemists who synthesized tabun (quite by accident) and other nerve agents in the late 1930s.

—Eric A. Croddy

See also: Aum Shinrikyo; Nerve Agents

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ARSENICALS

Arsenic (As) has long been recognized for its highly toxic properties, as a pure metal or, more often, in its oxide form. Chemical experts in the Chinese People's Liberation Army (PLA) have written: "In the year 1000 (A.D.), there was one named Tangfu, who made poison fire grenades and gave them to the Chao court of the Song dynasty. The poisonous smoke ball, containing arsenic oxide (As_2O_3) and a type of poison derived from crotonaldehyde, looked a bit like a precursor to a chemical gas grenade. After lighting its fuse, this weapon would belch out smoke poisoning the enemy, and thus weakening their ability to fight" (Cheng and Shi, p. 7).

Metallic arsenic (and its use as a poison) has been responsible not only for countless murders, but it was also responsible for a horrific environmental catastrophe in Bangladesh. By the late twentieth century, some 70 million people in Bangladesh were at risk from arsenic poisoning from contaminated groundwater.

In CW, numerous toxic compounds containing arsenic, roughly categorized as arsenicals, were developed during World War I. Arsenicals first appeared in the form of substances that are immediately irritating to the eyes, nose and throat—such as diphenylcyanoarsine—but blister-causing types of agent (vesicant) also formed a significant part of the chemical weapons used during the war. (Lewisite, arguably the most important arsenical agent, was not used in World War I because it was invented too late for use on the battlefield.) The Japanese military made use of arsenicals, especially diphenylcyanoarsine, against Chinese troops on the mainland and Taiwan in the 1930s. Japanese forces also may have used lewisite (or a close analogue) during World War II, but only against Chinese forces. Other references have suggested that lewisite has never been used in appreciable amounts in warfare. By the end of World War II, both the United States and Germany had stockpiled large quantities of lewisite for chemical munitions, but those were later supplanted by more effective CW agents such as the highly toxic organophosphates (i.e., nerve agents).

It is difficult to conceive of most arsenicals in the same vein as weapons of mass destruction (WMD). Highly toxic lewisite is certainly a well-known CW agent, but other arsenic-based organic compounds are better described as irritating or riot control agents (RCAs, or tear gas). Also referred to as a vomiting agent, diphenylaminochlorarsine (DM) was independently invented by the German chemist Heinrich Wieland in 1915 and the American chemist Major Roger Adams in 1918. This RCA is often referred to as adamsite. It is not likely to be considered a CW agent with enough toxicity to warrant being used as a WMD. Even so, this and other arsenicals are extremely toxic, much more so than compounds such as CS tear gas (*see* adamsite).

One of the first arsenic-based chemicals used as a means of warfare was arsine gas (AsH_3). Despite its high toxicity, early efforts in weaponizing arsine were frustrated by its flammability. (Attempts during World War I to use hydrogen cyanide [HCN] failed for the same reason.) Chemical weapons designers in World War I then looked to organic compounds containing arsenic, such as ethyldichlorarsine, the effects of which had been well described as early as 1880. As LaCoste wrote, "[Ethyl dichlorarsine] has a very powerful irritant action on the mucous membranes of the eyes and nose, causes painful blistering of the skin, and is very dangerous for those working with it, since its vapor causes respiratory [distress], faintness, and long lasting paralysis and [numbness] of the extremities" (Vedder, 1925, p. 173). Drawing upon this knowledge, German chemical weapons scientists first used an arsenical in an artillery munition called Blue Cross, which contained mostly diphenylchlorarsine and diphenylcyanoarsine.

There were specific, tactical reasons for choosing arsenical compounds for battlefield use. By 1917, most belligerents were well prepared against inhalation threats on the battlefield. Since the introduction of gas warfare in 1915, the use of improved protective masks had reduced casualties produced by chlorine, phosgene, and other agents. Military chemists had not been able to devise substances that could break through gas masks, directly attack the skin, or both. The use of arsenicals such as diphenylchlorarsine ("Clark I") and diphenylcyanoarsine ("Clark II") was intended to render gas masks ineffective by delivering these agents in a fine aerosol, producing very small particles that would penetrate the filters used in protective masks at the time. (In fact, the term *aerosol* has its origins in research in the early twentieth century regarding the behavior of irritating arsenical smokes. See also Aerosol.) Because of their extreme irritation of the nose and throat, these CW agents earned the appellation of sternutators or sneeze producers. Their use was intended to force removal of the mask, making the enemy vulnerable to further assault with other toxic agents.

In September 1917, Germany launched the first significant barrage against Russian troops using diphenylchlorarsine at Uexhuell near the Dvina River. In July 1918, German military headquarters reported the following about Blue Cross shells: "In sufficient concentrations it penetrates the French mask effectively and the English mask to a lesser degree, in which case it forces the enemy to tear off their masks. For this reason a mixture of blue and green cross [that is, pulmonary irritants such as phosgene] is recommended" (Vedder, p. 174).

The German development of diphenylcyanoarsine was even more effective than its predecessor, diphenylchlorarsine. Augustin Prentiss, a World War I contemporary and expert on chemical weapons, commented on this CW agent: "In diphenylcyanoarsine, we have the extreme limit of effectiveness in low concentrations of all chemical agents used in the war. Thus, a concentration of 0.00025 mg. per liter is intolerable if inhaled for 1 minute. As a man at rest normally inhales 8 liters of air per minute, he would absorb only 0.0002 mg of the substance in that time. This is, however, sufficient to incapacitate him for an hour. For an average man, weighing 154 lbs (70,000,000 mg), this means that diphenylcyanoarsine is effective in the ration of 1:35,000,000 of body weight, which makes it the strongest of all the known irritants" (Prentiss, p. 211).

It proved difficult, however, to deliver these Blue Cross agents in particles small enough to achieve the desired effect of being a reliable mask breaker. Among the American Expeditionary Forces that had by this time entered the fray, statistics compiled found that only 577 casualties and 3 deaths were caused by these respiratory-irritant chemicals. Other statistics from casualty reports of the war support the conclusion that Blue Cross agents were not very successful.

By September 1918, Germany also had introduced phenyldichlorarsine, ethyldichlorarsine, and ethydibromarsine as toxic lung agents. In addition to its highly irritating effects, ethyldichlorarsine was recognized for its toxicological properties as a vesicant or blister agent.

The Arsenical Vesicants

The blistering effects of some compounds, including the arsenical ethyldichlorarsine, were utilized to some degree in World War I. By 1918, however, sulfur mustard became the dominant blister agent on the battlefield and the cause of most chemical casualties in the entire war. German military commanders saw a potential role for a CW agent that was fast-acting, more volatile, and would clear an area more quickly than mustard. Ethyldichlorarsine had such properties. In contrast, sulfur mustard caused injury only after considerable delay but was much more persistent, making it more suitable for defensive operations. Because Germany was planning a major offensive by spring 1918, ethyldichlorarsine was produced for the western front by March of that year. Referred to by the Germans as Dick and coded Yellow Cross I (differentiating it from Yellow Cross, which was sulfur mustard), its overall impact as a vesicant was largely overshadowed by its lung-irritating properties. It is not clear how many casualties were caused due to Yellow Cross I, including its less toxic relative, ethyldibromarsine.

Dr. W. Lee Lewis, an American chemist, invented chlorovinyldichloroarsine, which was subsequently named lewisite in his honor in 1917. It also was called the dew of death, given its possible use by dissemination from aircraft. Lewisite is a true vesicant as well as a highly irritating CW agent, and it may have been manufactured by Germany at the same time of Lewis's discovery. If Germany did manufacture lewisite in quantity, it is unknown why they did not use it. Full-scale manufacture of lewisite by the United States began at a facility in a Cleveland, Ohio, suburb in 1918. Before the Allies could employ lewisite in World War I, however, the armistice had brought an end to the conflict. Lewisite had already been shipped across the Atlantic, and due to its instability, it was dumped into the ocean for quick disposal.

Lewisite is absorbed through membranes of the skin, causing extreme irritation and blistering, as well as destruction of tissue in the upper respiratory tract. Lewisite has potent damaging effects on the eyes, and exposure without adequate decontamination may cause blindness. It is believed that the toxicological action of lewisite focuses upon inhibition of enzymes in the body.

Following World War I, military chemists compared the inhalation exposure toxicities of various arsenicals and blister agents (e.g., mustard), ranking them in order of most toxic to least toxic (figures are from Prentiss, 1937):

Table A-11: Toxicity of Arsenical Vesicants

Agent	
Lewisite	Most Toxic
Mustard	
Phenyldibromarsine	
Phenyldichlorarsine	
Ethyldichlorarsine	
Methyldichlorarsine	
Dibromethyl sulfide	Least Toxic

According to a Chinese text on chemical weaponry, which draws upon a reference by Franke (1967):

> Lewisite is a colorless, oily liquid that in its actual production takes on a brown color. Very low concentrations of Lewisite vapor produce an odor similar to geraniums. The volatility of lewisite is greater than that of mustard, easily forms high densities on the battlefield, and one does not need to add anti-freezing solvents to use lewisite during winter. Because of these properties, and the very close relationship between lewisite and mustard, they are often used in tandem. Lewisite hydrolyzes in water faster than mustard, but in this instance the degradation products are toxic. Additionally, lewisite in its liquid form penetrates the skin at a rate 3–4 times faster than mustard (Cheng and Shi, p. 17).

The mixing of lewisite with mustard was, in fact, a common practice in the Japanese military's use of vesicants, as well as in Soviet doctrine for chemical munitions. The need for this chemical cocktail was caused by the fact that sulfur mustard congeals at a relatively high temperature. Mixing mustard with solvents, including not only lewisite and other chlorinated hydrocarbons but also the nerve agent diisopropyl fluorophosphate (DFP), has been done to bring down the freezing point of mustard for use in winter.

In addition to the blistering and the irritant effect on skin, eyes, and the respiratory system, lewisite also serves as a systemic poison. Skin damage as a result of lewisite exposure, however, is expected to heal faster than that caused by mustard. Effects of lewisite on skin, including extreme pain and redness, occur within minutes of exposure, with blisters forming about 10–15 hours later. As in the case of mustard exposure, the first approach to treating victims of lewisite exposure is thorough decontamination. But there is also a chemical antidote using chelation therapy, that is, the use of chemicals to "grab" arsenic from solution. Because arsenic has affinity for certain chemical groups, especially sulfur, compounds such as dimercaprol, traditionally called British Anti-Lewisite (BAL), have been found effective in treating lewisite poisoning. Not enough data exist on human cases, however, to determine the extent of its efficacy. More recent improvements upon BAL include therapeutics that can be administered orally, namely the water-soluble dimercaptosuccinic acid (DMSA) and dimercapto–1-propanesulfonic acid (DMPS).

Although arsenic is poisonous, it has multiple uses in civilian applications. Due to its ubiquity, some arsenic compounds are controlled out of concern that they could be used to produce chemical weapons. For example, a common method of manufacturing lewisite is to start with arsenic trichloride ($AsCl_3$), a precursor that is restricted by the Chemical Weapons Convention (CWC). By the same token, existing stocks of lewisite that are slated for destruction may be recycled for peaceful uses. Because the former Soviet Union had a considerably large stockpile of lewisite-filled munitions (often mixed with sulfur mustard), chemical demilitarization efforts have focused upon extracting arsenic from lewisite stocks for recycling. Arsenic is used in a variety of industrial process, including gallium-arsenide semiconductor chips, although it is unclear whether such a venture is economically viable. Arsenic is still utilized in formulations for insecticides and in fungicidal treatments for lumber.

—Eric A. Croddy

See also: Vesicants; World War I

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ATROPINE

The first line of defense against nerve agent poisoning is a drug called atropine. This compound has been used for centuries in various ways, one of these being to cause the dilation of the pupils in the eyes. At one time, it was very fashionable in Europe for women to have dilated pupils, and extracts from the belladonna plant were used for this purpose. (The same is done today for eye examinations; atropine is used to widen pupils to allow the practitioner to see better into the patient's retinal space.) This drug and others like it are still referred to as the belladonna group of compounds, from the Italian for *beautiful lady.* Atropine, a so-called alkaloid (nitrogen-carbon compounds that are noted for their pharmacological effects), is found in the deadly nightshade plant (*Atropa belladonna*) and in other related species of the genus *Solanaceae,* such as henbane. Related compounds that have similar effects include scopalomine. The latter drug has significant hallucinogenic properties and is the toxic principle in Jimson's weed (*Datura*). This family of compounds has been thoroughly investigated by chemical warfare programs in the United States, former Soviet Union, and Warsaw Pact nations (including East Germany). Some analogues were found to have potential value as incapacitating agents, such as BZ, the code name of one of these agents (3-quinuclindinyl benzilate).

The effects of the belladonna and *Datura* alkaloids on the human body have been known for centuries. Symptoms of atropine intoxication can be described in well-known similes: Blind as a bat (pupils become excessively dilated, blurring the vision); dry as a bone (atropine shuts down the sweat glands); red as a beet (atropine causes the skin to flush through dilation of the blood vessels); mad as a hatter (for its hallucinogenic and behavioral modification); and hot as a hare (lack of perspiration causes body temperature to rise). Although very small amounts of these drugs can cause physiological symptoms, humans can tolerate significant doses of atropine. One immediate danger from atropine intoxication is the propensity for hyperthermia.

Militaries and emergency responders can treat nerve agent casualties with atropine and oxime. (Reuters/Corbis)

Atropine is primarily known for its life-saving, diagnostic, and therapeutic uses in health care settings. There have, however, been instances when atropine has been utilized as a potential mass casualty weapon, including a plot to cause mass poisoning. In the late 1950s, a large number of saltshakers in a cafeteria that served employees of Radio Free Europe were adulterated with atropine, enough to have caused serious poisoning at least (although probably not death). The plot was foiled when a spy alerted the authorities about the poisoned salt, later assayed to find about 25 milligrams of atropine per shaker.

Relatively large doses (up to 1 gram) of atropine may be called for to treat cases of exposure to organophosphate insecticides, and there is a very different set of treatment protocols and treatment duration for these than for military nerve agents. Following exposure to a toxic organophosphate, administration of atropine counterbalances dangerously high levels of the neurotransmitter acetylcholine, a condition brought on by the effects of nerve agents (e.g., sarin). Nerve agents, having blocked or inhibited the function of acetylcholinesterase (AChE) enzyme that keeps the acetylcholine levels in balance, results in an increase in acetylcholine molecules. This chemical stimulates receptors in the nervous system, causing exhaustion in the breathing muscles, changes in heart rhythm, and secretions in the throat that can asphyxiate the victim. Atropine, on the other hand, is a so-called anticholinergic compound: it partially blocks receptors in the nervous system, protecting them from excessive levels of acetylcholine stimulation. Although atropine does little for involuntary twitching in skeletal muscles, it does help to dry up secretions and restore some normalcy to the rest of the nervous system.

Longer-term treatment of nerve agent poisoning may include administering chemical compounds called oximes. These help restore the normal activity of AChE by releasing the enzyme (via dephosphorylation, the breaking of the phosphate-enzyme bond) from the nerve agent's blockage. Oxime treatment in conjunction with atropine increases the chances of survival for victims exposed to nerve agents.

Atropine for treatment of nerve agents is fielded in the form of autoinjectors. These are spring-loaded syringes that deliver an intramuscular injection of 2 milligrams of atropine. A Chinese military textbook recommends the following doses for nerve agent exposure, which are typical of those found prescribed by various armed forces: "1–2 mg for light injuries, 3–5 mg for moderate, and 5–10 mg for serious exposures. If symptoms have not lessened in their severity after 10–30 minutes, one should consider increasing the above dosage. *Datura* and other Chinese medicinal herbs can also provide therapeutic benefit." (Cheng and Shi, p. 82).

The effects of atropine injected in humans at varying doses have been described in the existing literature. At 0.5 milligrams, there is dryness of the skin with a slowed heart rate. Between 1 and 2 milligrams, one sees dilation of pupils (madriasis) and faster heartbeats. Above 10 milligrams, there is delirium, apathy, and hallucinations, followed by unconsciousness. In the absence of nerve agent poisoning, the doses delivered in autoinjectors (2 milligrams) are tolerated quite well. In the false belief of a nerve agent attack during the Gulf War (1991), many Israeli citizens self-administered atropine in the midst of Iraqi Scud missile raids. No untoward effects were reported.

—Eric A. Croddy

See also: Nerve Agents; Psychoincapacitants

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AUM SHINRIKYO

The Japanese apocalyptic group Aum Shinrikyo ("Supreme Truth") is generally credited with opening the Pandora's box of WMD terrorism with its sarin attack on the Tokyo subway system on March 20, 1995. Although this was not the first ever chemical or biological terrorism attack, it was of such a scale (5 trains on 3 separate lines attacked nearly simultaneously, resulting in 12 deaths and more than 1,000 people seriously injured) that it is generally regarded as the benchmark for the beginning of modern WMD terrorism. The subway attack was not the first Aum Shinrikyo chemical terror attack. It was preceded by attempts to develop and employ biological weapons. Thus, Aum Shinrikyo stands as a valuable case study regarding both the dangers of WMD terrorism and of the significant difficulties that even a well-financed group with internal technical expertise might encounter in employing WMD for mass casualty effects.

Aum Shinrikyo represented, at once, a "new religion," a political movement, and a fanatical apocalyptic cult willing to use mass casualty terrorism to accelerate and achieve what it saw as its preordained destiny. Aum Shinrikyo was founded by Shoko Asahara, based on the belief that Armageddon was inevitable and that only the devout believers in Aum Shinrikyo would survive the end of the world. As a religion, Aum Shinrikyo was successful in drawing recruits and donations. The group specifically targeted its recruitment at technical universities, and the group enjoyed a relatively well-educated and wealthy membership. At the same time that it was experiencing growth in membership and wealth, Aum Shinrikyo was singularly unsuccessful as a legitimate political movement, losing all of the Japanese elections in which it fielded candidates. The group was able to employ its wealth and some of its technically expert members, however, to support its WMD terrorism program. Even though Japanese authorities compiled a growing body of evidence on Aum Shinrikyo's terrorist objectives and chemical and biological programs preceding the Tokyo subway attacks, they hesitated to take action against the group because of provisions in Japanese law protecting religious freedom and practice. Aum Shinrikyo enjoyed the benefits as a self-described religious organization in furthering its political agenda through terrorism.

The inner cadre of Aum Shinrikyo's leadership was organized into a "shadow government," with a structure directly mirroring Japan's executive department and functions. Individual Aum Shinrikyo leaders were assigned positions in the shadow government to prepare them to assume the corresponding duties in the new order. Aum Shinrikyo blended a "new religion" veneer with a political core that was characteristic of traditional terrorism. Their preparedness to assume governmental functions complemented their absolute opposition to the existing government, inspiring preparation for violent action to accelerate or augment the coming apocalypse and to protect the group until that day arrived. Aum Shinrikyo developed hierarchical operational organs, a highly sophisticated infrastructure, and extensive support mechanisms. Using the broader religious periphery for first-level recruitment and basic funding, Aum Shinrikyo developed business enterprises and internally selected technical experts to support its action program. These included both conventional, chemical, and biological weapons labs derived from legitimate cover enterprises. The Aum Shinrikyo weapons program was ultimately as well financed and technically supported as many smaller programs of Japan's actual government. So, although Aum Shinrikyo was a broad-based and large, horizontal religious movement, it contained a vertically stratified and tightly disciplined action cadre at its political center.

The several violent actions carried out by the Aum Shinrikyo cadre looked much like traditional terrorism—the same individuals were involved in planning and executing the organization's terrorist acts, this group acted in close concert with an equally small and disciplined direct support cadre, and all were under the direct control of the central leadership of the group. The major difference between Aum Shinrikyo and traditional terrorists was that Aum Shinrikyo only used WMD in its attacks.

Aum Shinrikyo tried to develop and employ biological and chemical weapons as early as 1990. Testimony during the legal proceedings following the 1995 Tokyo subway attacks indicated that the targets of the mostly unsuccessful attempts included the general Japanese public, specific group rivals, disaffected cult members, investigative journalists, the Japanese legal system and government, members of the Japanese royal family, and United States military installations in Japan.

Aum Shinrikyo had extensive biological and chemical agent development programs, but their actual employment of WMD presents a very mixed story. As early as April 1990, the group attempted to employ botulinum toxin for mass casualty effects in Tokyo. The attack coincided with an island retreat by the Aum Shinrikyo leadership and membership, so that the group itself would not fall victim to the attack. The group attempted to disperse the toxin from truck-mounted dispensers: one outside the Diet (national parliament) building downtown, one outside the U.S. naval facilities in the southern port suburbs, and one at Narita International Airport. The attack failed when the dispenser sprayers may have killed the toxin in the dispersal process, or more probably the toxin was ineffective from the beginning. Aum Shinrikyo was forced to return to the drawing board.

The group again attempted to disperse botulinum toxin in June 1993, again from a truck-mounted spray dispenser. The target in this attack was the gathering of world dignitaries in conjunction with the wedding of Crown Prince Naruhito. This attack suffered the same fate as the 1990 botulinum attack: The dispersal system exceeded the environmental parameters and would likely have rendered the toxin ineffective.

Aum Shinrikyo then turned to anthrax as its agent of choice. Just weeks after the 1993 royal wedding attempt, the group dispensed anthrax from the roof of a cult-owned building in downtown Tokyo. Although a few people reported being affected by noxious fumes, this attack also failed to cause casualties. The anthrax strain Aum Shinrikyo used was an American animal vaccine strain, not a toxic strain.

Aum Shinrikyo's initial unsuccessful experiences with biological weapons caused the group to switch to chemical weapons. Beginning in 1993, reports suggested they had successfully experimented with sarin employed against sheep on a cult-owned ranch in Australia. (Later investigations, however, showed that tests on the sheep carcasses may have confused sarin with commercial pesticides used in "sheep dip.") Early in 1994, they chose the leader of a rival "new religion" and its associated political party as their victims, but the field application of their chemical weapon was unsuccessful when their effort to create a gaseous form of sarin resulted in the dispersal van catching fire. Aum Shinrikyo continued to rely on chemical attacks as their primary form of action, both to exploit their economic and technical capabilities in this arena and to further their end goal of creating broader effects to hasten the ultimate global conflict that would usher in their rise to power. Toward this end, Aum Shinrikyo was certainly willing to accept mass casualties; however, they continued to encounter problems with dispersal and application of WMD.

The group's second sarin attack, in June of 1994, also was not fully successful. It was intended to kill three judges who were presiding at a trial involving Aum Shinrikyo. The plan to gas the judges, their courthouse, and an adjacent police station was meant to be an attack on the justice system that was posing a threat to Aum Shinrikyo. Poor planning caused the attack team to arrive after the judges had left the courthouse, and the subsequent plan to attack their apartment complex failed when the gas dispersed too widely and the wind shifted, leading to only limited effects on the specific apartments of interest. The target judges fell ill, but they were not among the seven who were killed in the attack.

The March 1995 Tokyo subway attacks represented a direct application of terrorism for the dual purposes of producing mass casualties and intimidating the authorities for self-preservation. Japanese national police under the Ministry of Justice had finally amassed sufficient evidence to mount a raid on the Aum Shinrikyo compound and chemical weapons laboratory. The raid was set for March 22. Aum Shinrikyo first attempted to cause mass casualties at the Kasumigaseki subway station using botulinum toxin on March 15. Besides the disruptive effects of a mass casualty attack, Kasumigaseki station served as the Ministry of Justice headquarters, and the timing would have meant that many of the passengers on those trains should be Ministry of Justice employees. Aum Shinrikyo hoped to delay or divert the Justice raid on their own headquarters, which they had been tipped off was imminent. In this case, the group used dispensers hidden in briefcases, but the dispersal again failed.

Aum Shinrikyo then reverted to sarin, and they again attacked the subway system on March 20. This subway attack employed an unsophisticated dispersal method—plastic bags of liquid sarin punctured by the pointed ends of umbrellas. The operation involved rush-hour attacks on five separate subway trains in the Tokyo system, trains that were all due to arrive at Kasumigaseki station shortly before eight o'clock on a weekday morning. The earlier purpose and plan still applied: targeting Ministry of Justice employees, many of whom would be on those trains. Because of the primitive dispersal method, the five attacks resulted in many fewer casualties (12 killed, 1,000 injured) than might have been anticipated given the quantity of sarin involved, and the attack ultimately precipitated a much more complete investigation and prosecution of Aum Shinrikyo.

Finally, as the investigations and arrests following the March 1995 subway attacks began, Aum Shinrikyo returned to the Tokyo subway system one more time. On May 5, 1995, the group attempted to employ cyanide in Shinjuku station. In this case, the dispersal system involved sequential use of acid, then cyanide, but the device was discovered before it could do any harm.

Aum Shinrikyo had only limited success in fourteen separate biological and chemical attacks. The group employed or attempted to employ sarin and cyanide, as well as VX and phosgene gas. In terms of biological weapons, Aum Shinrikyo at various times was developing or seeking to develop anthrax, botulinum, Q-fever, and even Ebola for use as weapons. Aum Shinrikyo had up to twenty people dedicated to biological weapon production and testing. After the Tokyo subway attack, Japanese police found enough sarin precursors in the group's possession to produce tons of sarin nerve agent. At that time, work at Aum Shinrikyo labs also suggested that the group was continuing to develop or experiment with a variety of nerve agents—including VX, soman, and tabun—and other chemical weapons such as mustard and sodium cyanide. As many as eighty Aum Shinrikyo members worked on chemical weapons development.

Aum Shinrikyo also was involved with, and had specific interest in, both nuclear and conventional weapons. Nuclear weapons represented the ultimate apocalyptic tool to Aum Shinrikyo's leadership. The group widely sought nuclear weapons materials and expertise—from Australian uranium to Russian lasers (an experimental technology for producing fissile materials). They also showed interest in other "exotic" weapons that had relevance to Japan, including seismological weapons. They also procured and produced conventional weapons, notably the AK-74 rifle. The group's AK-74s were used for training and arming a small paramilitary cadre, and they served as a source of some revenue to Aum Shinrikyo. The variety of weapons and systems that Aum Shinrikyo procured, as well as insight into their future plans, was demonstrated by their efforts late in the group's action phase to employ a Russian military helicopter as well as some unmanned drone aircraft, all outfitted with aerial spray dispersal systems for chemical weapons.

Although the Aum Shinrikyo leadership, terrorist planning and operational cadre, and WMD technical development personnel were arrested, tried, and imprisoned after the Tokyo subway attacks, the group as a religious movement still exists in significant numbers, primarily in Japan and in Russia. Estimates from 1995 were that Aum Shinrikyo had more than 40,000 followers, with almost 30,000 of those in Russia, approximately 10,000 in Japan, and smaller numbers in other countries, primarily the United States and Germany. That same year, Aum Shinrikyo's financial assets were estimated at 1 billion dollars.

Aum Shinrikyo stands as the "poster child" for both the extreme threat of WMD terror and the difficulties faced by a nonstate actor in delivering on that threat. Aum Shinrikyo had several unique advantages that allowed it to advance its WMD terrorism program. It had a multilayered organization that allowed its religious component to serve as both cover and sponsor for its terrorism element. It had access to an array of resources—from millions of dollars in funding to member scientists to group-owned chemical companies for facilities and cover. And, significantly, the nature of its religious foundation—particularly as interpreted after the breakup of the Soviet Union and the concurrent display of United States conventional military power in the 1991 Gulf War led Aum Shinrikyo's leaders to conclude that a global apocalypse was not as imminent as they once thought—allowed the group to turn conventional wisdom that terrorists want many observers and few casualties on its head.

Even with all these advantages, however, Aum Shinrikyo's experience highlights several of the daunting obstacles that stand in the way of any group seeking to develop and employ WMD for the purposes of terrorism. First, although Aum Shinrikyo was able to procure dangerous chemical and biological agents, it was not able to gain access to some of the highly lethal biological strains that it sought. Safeguards on these strains do provide some significant protection against groups without state sponsorship attaining specific materials. Second, the dispersal problem for chemical and biological agents is very real, and even a well funded and technically gifted cadre within a terrorist group will face significant challenges in agent dissemination and utilization in the field. Third, the cold scientific rationality required to overcome these technical hurdles can be overshadowed by the emotional and ideological imperatives of terrorist leaders—the "action program" may not have the patience needed to allow the agent development side to complete its work. In the end, WMD terrorism remains a very real but difficult-to-deliver-on threat.

—*James M. Smith*

See also: Bioterrorism; Nerve Agents; Sarin

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THE AUSTRALIA GROUP

The Australia Group is an informal network of thirty-three countries and the European Commission that aim to ensure that their exports do not contribute to the development of chemical or biological weapons. The Australia Group does this by licensing the export of certain chemicals, biological agents, and dual-use chemical and biological manufacturing equipment that can be used in CBW programs, based on common control lists.

History

In April 1984, a special investigation mission sent by the UN Secretary General to Iran found that chemical weapons (CW) had been used against Iran in the Iran-Iraq war, which was a clear and unequivocal violation of the 1925 Geneva Protocol. There was also evidence that Iraq had obtained materials for its CW program from the international chemical industry. In response to these findings, a number of countries placed licensing measures on the export of certain chemicals used in the manufacture of chemical weapons.

The countries concerned saw an urgent need to address the problem posed by the spread of CW and ensure that their industries were not, either deliberately or inadvertently, helping other countries to acquire and use such weapons in violation of international law and norms.

The measures originally imposed by these countries, however, were not uniform either in scope or application. It also became apparent that attempts were being made to use this lack of uniformity to circumvent these initial controls. This led Australia to propose, in April 1985, that representatives from the fifteen countries that had introduced licensing for exports should meet to examine ways to standardize the measures taken at the national level to prevent illicit trafficking in chemical weapons precursors.

The first meeting of what came to be known as the Australia Group (AG) took place in Brussels, Belgium, in June 1985. Participating countries agreed that there was benefit in continuing the process, and meetings of the group are now held in Paris on an annual basis. The emergence of increasing evidence of diversion of dual-use materials to biological weapons programs in the late 1980s led participants to take steps to address the increasing problem of the spread of BW.

Technical Details

AG participants have developed, through a consensus approach, common export control lists, which specify items that each AG participant undertakes to control through its respective national export licensing procedures.

Licensing procedures allow each participating country to consider whether a particular export could contribute to CBW and therefore breach the country's obligations under the Biological and Toxin Weapons Convention (BTWC) or the Chemical Weapons Convention (CWC). Every export license application is examined by the national authority on a case-by-case basis, with the decision about whether to supply the requested items resting solely with the country approached. An export request is denied only if there is particular concern about potential diversion for CBW purposes.

Australia Group participants have committed to consult each other before exporting items that another participant has previously denied because of proliferation concerns. This commitment to consult is referred to as a no-undercut policy, but it does not constitute a binding ban. Group participants also have implemented a catch-all provision, whereby a participant will not supply an item that is not on export control list when there is particular concern about potential diversion of the item for CBW purposes.

Group participants ensure that their countries' private sectors are informed of the dangers inherent in the uncontrolled export of dual-use chemicals and biological materials and equipment. Chemical and biotechnology companies, and traders conscious of their public image and corporate responsibilities, have welcomed the assurances provided by the controls implemented by Australia Group participants. The transparency generated by the Australia Group's activities increases confidence, creating an environment more conducive to the normal flow of commercial goods, equipment, and technology.

Current Status

Participating countries in the Australia Group are Argentina, Australia, Austria, Belgium, Bulgaria, Canada, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Japan, Republic of Korea, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Slovakia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. The European Commission is also a participant. Australia chairs the group and provides a secretariat within its Department of Foreign Affairs and Trade.

There are presently five common control lists covering fifty-four CW precursors: dual-use chemical manufacturing facilities and equipment and related technology; dual-use biological equipment; and biological agents, including plant pathogens, animal pathogens, and toxins.

The common control lists are reviewed and adjusted periodically to ensure their continued effectiveness. Australia Group members believe that export control measures should be effective in impeding the production of chemical and biological weapons, be practical and reasonably easy to implement, and not impede the normal trade of materials and equipment used for legitimate purposes.

All countries participating in the Australia Group are State Parties in good standing to both the CWC and BTWC. These countries consider the implementation of national licensing procedures based on the various AG lists as an essential means to ensure that they are fully implementing their nonproliferation obligations under Article I of the CWC and Article III of the BTWC. In applying export licensing procedures, group participants also seek to ensure that international trade in chemical and biological products for peaceful purposes is not hindered, in accordance with Article XI of the CWC and Article X of the BTWC.

Future Developments

Since its inception, the Australia Group has proven to be an important element in ongoing international efforts to impede the proliferation of chemical and biological weapons. Recent developments, however, have challenged the effectiveness of national export licensing measures. Economic globalization has seen the number of potential chemical supplier countries grow considerably. The rapid pace of technological change, particularly in the biotechnology sector, also poses new challenges for keeping common control lists up to date. Monitoring intangible technology transfer (know-how) is being increasingly complicated by rapid advances in communications and information transfer. Terrorists, not state actors, are now seen as being a potential CBW threat, but the Australia Group has not developed controls that are optimized to prevent terrorists from acquiring chemical precursors.

In response, recent technical reviews of the Australia Group's common control lists have taken into account changing technologies and chemical and biological terrorism issues. In addition, group participants are encouraging all exporting and transshipping (that is, goods being shipped across national borders) countries to implement similar measures. In recent years, the group has maintained a practice of briefing a large number of nonparticipating countries on the outcomes of its meetings. These briefings make available lists of chemical and biological agents and related equipment and technologies that are of proliferation concern, and they have helped other countries to adopt export control measures.

Although a small number of countries criticize the Australia Group for what they claim are restrictions on legitimate trade and technology transfers, there appears to be an increasing acceptance by most countries of the idea that adopting national export licensing measures based on the Australia Group's common control lists raises the barriers to both chemical and biological weapons proliferation and chemical or biological terrorism. Many countries also believe that the group provides a tool for implementing nonproliferation obligations under the CWC and BWC. A number of group participants and other countries have also used the various common control lists as a basis for domestic monitoring of listed items, as a means to increase the barriers to terrorism. The importance of the Australia Group and the use of lists of chemical and biological materials of concern are likely to increase in the years ahead.

—Robert Mathews

See also: Biological and Toxin Weapons Convention; Chemical Weapons Convention; Dual-Use

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B

BARI INCIDENT

On December 2, 1943, in what came to be referred to by some as a second Pearl Harbor, German JU-88 bombers attacked the port city of Bari, Italy, sinking seventeen Allied ships and damaging several others. Among the American vessels fatally struck that night was the Liberty class cargo ship SS *John Harvey,* which, in addition to its typical load of conventional arms, food, and other supplies, carried 2,000 one-hundred pound M47A1 bombs filled with the blister agent sulfur mustard (*see* Mustard [Sulfur and Nitrogen]). Due to the sensitive nature of, and thus the compartmentalized information regarding this cargo, only a select few crew members were aware of this dangerous freight. Unfortunately, all of these crew members were killed in the attack, leaving medical personnel ashore unaware of the need to treat casualties for blister agent exposure. Of approximately 800 American military casualties hospitalized following the raid, more than 600 were eventually diagnosed with gas exposure, and 83 of those died. Numbers of civilian casualties are less well documented, but estimates run as high as 1,000.

Although he had issued a statement denouncing the use of chemical weapons by any actor in World War II, President Franklin Delano Roosevelt had also reserved the right to retaliate in kind if chemical weapons were used by the Axis. He therefore ordered mustard-filled munitions to be forward deployed in Europe to provide the capability to launch a retaliatory strike in the event that the Germans initiated gas warfare. In 1943, the Germans were on the defensive. As a consequence, or so the Allies believed, Germany could have been desperate enough to use poison gas on the battlefield. To avoid triggering a preemptive strike by Germany with chemicals, however, the presence of the Allies' chemical munitions was kept secret. This was to play a tragic role in what transpired off the Italian coast.

Being oil miscible, liquid mustard released into the harbor waters mixed with oil from stricken vessels. This mustard agent came into contact with sailors who had dived into the water to escape their sinking ships. Sulfur mustard vapors were also released into the air. Because medical personnel were unaware of the mustard's presence, rescued seamen were allowed to remain in their oil-soaked clothing while those injured in the blasts were treated, prolonging contact with the agent. Victims began to exhibit the delayed effects of mustard exposure within hours, with burns on their skin, swollen eyes and genitals, and temporary blindness. More serious casualties were those involving respiratory exposures of mustard agent.

After the bombing, medical personnel at Bari, finding the symptoms exhibited by their patients to be consistent with blister agent use, called for an investigation. U.S. Army Medical Corps Lieutenant Colonel Stewart Alexander, a chemical warfare expert, travelled to Bari, where he determined mustard to be the source of the nonblast casualties. In February 1944, the U.S. government issued a statement acknowleging the presence of mustard in the *John Harvey's* cargo.

After the war, the United States disposed of unspecified amounts of phosgene, hydrogen cyanide, cyanogen chloride, and additional quantities of mustard off the coast near Bari. Studies performed by the University of Bari as recently as 1997 have discovered cases of mustard exposure among fisherman trawling these waters.

—Claudine McCarthy

See also: Mustard (Sulfur and Nitrogen); Vesicants; World War II: Chemical Weapons

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BHOPAL, INDIA: UNION CARBIDE ACCIDENT
The Bhopal, India, Union Carbide accident is an example of how industrial chemicals—whether in precursor, intermediate, or finished form—have the potential to create massive casualties. The accident also provides a window into the possible outcomes of an intentional release of CW agents.

On the night of December 3, 1984, Bhopal and its environs fell victim to the worst industrial accident in human history. As the city slept, approximately 40 tons of the highly toxic industrial chemical methyl isocyanate (MIC) escaped from two underground storage tanks, blanketing the highly concentrated population in an invisible, choking cloud. The gas cloud, trapped under a nocturnal temperature inversion, engulfed a 5-mile-wide perimeter, claiming the lives of thousands of men, women, children, and animals in its wake. The disaster is explained by the high toxicity of MIC, a more potent choking gas than phosgene. To compare, the safety limit for MIC exposure in humans over an 8-hour period is 0.02 parts per million (ppm), but phosgene is rated at 0.1 ppm.

Union Carbide India Ltd. (UCIL), a subsidiary of Union Carbide Corporation, first set up shop in 1934. Constructed in 1969, the company's Bhopal facility was originally designed for pesticide production, which required the mixing of stable chemicals. Finished pesticide would then be sold directly to the Indian government. The factory was located in close proximity to established working-class settlements in order to take advantage of the Bhopal-Ujain rail line.

In 1974, UCIL was licensed by the Madhya Pradesh (MP) government to manufacture 50,000 tons of pesticides per year. Soon, however, the market for finished pesticides began to wane, due in part to a decrease in cases of malaria and therefore in the need for mosquito abatement measures, but also because of aggressive competition from more than 300 smaller manufacturing firms. To cut production costs, UCIL began to manufacture key chemical intermediates instead of purchasing them from a separate supplier. In 1978, the plant was reconfigured to produce MIC, a volatile intermediate chemical used in the production of the carbamate (a category of chemical that has specific groupings of carbon, nitrogen, and oxygen) pesticide carbaryl (marketed under the trade name Sevin[r]).

The Bhopal plant had experienced a number of incidents prior to December 1984. Between 1981 and 1982, two separate phosgene gas (a chemical precursor of MIC) accidents claimed the life of one worker and injured twenty-four others. The plant suffered its first MIC leak in 1982. That incident injured four workers. Between 1980 and 1984, the number of UCIL operators assigned to the MIC unit was downsized to half its original strength. In May 1982, a confidential safety audit was conducted by a United States-based team. The team identified "61 hazards, 30 of them major and 11 in the dangerous phosgene/MIC units." Corrective measures were subsequently taken (Kalelkar, 1988).

The details of exactly how the lethal MIC was able to escape into the atmosphere on December 3, 1984, are still contested today. Much of the attention has focused on activity in the plant involving the use of water to flush the lines in the MIC manufacturing unit. This water, according to the Indian government's explanation, seeped inside the MIC storage tanks due to leaking valves. However, post-event investigations conducted by Union Carbide, the parent company, and by Arthur D. Little, an independent chemical industry consulting firm, found evidence of sabotage. In this scenario, a disgruntled worker may have deliberately introduced water into the tanks containing MIC, knowing that this would ruin the chemical used in the preparation of the final product. The individual probably had no inkling as to the ultimate consequences of his action.

Adding to the conditions that would portend disaster, three essential safety measures had been offline at the time of the incident. The refrigeration unit, which would have kept the tank temperature close to 0° centigrade, had been shut down in June 1984. Cooling the MIC to low temperatures might have reduced the ultimate reaction rate and volatility, but this is only speculation. Also, months before the incident, process vents—exhaust units for excess gases—were taken out for maintenance. Thus, the flare tower used to incinerate chemical exhaust that could have treated unwanted emissions was not available. Finally, the safety scrubber—another means of treating toxic effluents—had been turned off, although it was usable at the time of the incident.

In December 1984, up to 3,000 people died in the Bhopal, India, methyl isocyanate gas release. (Alain Nogues/Corbis Sygma)

The introduction of water into the tank with a volatile chemical at ambient temperature triggered a runaway, exothermic reaction. Although desperate efforts were taken by workers to control the gas release, these were futile and may have even added to the problem. Making the hazard worse still, numerous shantytowns had been built up around the plant, mostly because the land was government-owned and therefore rent-free. As a result, thousands of people were located close to the site of the MIC release.

Though the government reported that 3,800 people perished, other casualty estimates have ranged from 2,000 to 8,000 dead immediately following the accident. The government also reported that 40 people were left with permanent total disabilities and 2,680 people were left with permanent partial disabilities. Damage to renal, respiratory, reproductive, and sensory systems compounded most of the immediate injuries.

The years following the Union Carbide accident have seen a number of actions, each with varying results. In addition to medical recovery, the people of Bhopal now faced economic disaster. Immediately following the accident, the $25 million Bhopal production facility was closed at the cost of 650 permanent jobs. Months later, the neighboring research facility was cut to a skeleton staff. Two massive 3-week evacuations of the area led to business losses ranging from $8–$65 million. Although the government took steps to compensate the survivors, including monetary reparations and the construction of area hospitals, these efforts paled in comparison to the traumatic effects brought on by the accident.

At the same time, a number of lawsuits were filed against the Union Carbide Corporation in both the United States and India. After a long legal battle between the Indian government and the Union Carbide Corporation, which included a number of Congressional hearings and a battle over legal jurisdiction, an agreement was reached that ordered Union Carbide to pay $470 million to the Indian government in compensation. By 1993, after a number of bureaucratic procedural hurdles, distribution of the compensation finally began. As part of the dispersal plan, the Indian government intended to use the award for general community rehabilitation. Because this was not the original intent of the settlement, a public uproar ensued over the government's plan. As recently as 2002, the government backed down from this posture, stating that the money would be used for compensation to the victims. Relatives of the dead, and survivors suffering serious injuries, received an average of $3,000 apiece.

UCIL maintained a low profile in the post-Bhopal period. The aftermath of the accident sapped the economic strength of the corporation, leading to a buyout by its major competitor, Dow Chemical. Further lawsuits aimed at garnering additional compensation for the accident from Dow Chemical are currently pending.

—Brian L'Italien

See also: Carbamates; Choking Agents; Phosgene Gas

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BIGEYE (BLU-80)

Bigeye was the code name for a 500-pound binary chemical bomb designed by the U.S. navy for the delivery of VX nerve gas. *Binary* refers to the concept of using two nontoxic but poisonous substances that are mixed in flight to produce a lethal nerve agent. (*See* Binary Chemical Munitions.) This was done to ensure safer storage and handling of chemical munitions. Munitions already filled with chemical agents—so-called unitary weapons—had started to leak in the 1970s, and the Department of Defense was well aware of the negative public response to the dangers of these unitary chemical weapons. The Department of Defense needed a weapon that citizens would accept.

The Bigeye concept was conceived in 1959. Testing on Bigeye started in 1972, and about 200 test articles were produced at Pine Buff Arsenal, Arkansas. (Production never commenced, however, because the United States and the Soviet Union agreed to a chemical weapons destruction plan in 1990.) One canister of this binary weapon would be stored separately from the bomb itself and added just prior to flight (the bomb was to be delivered by plane). This separation would have extended the storage shelf life of the bomb and eased munitions maintenance requirements. Bigeyes were to be carried by tactical fighters, such as the A-6 and F-111, and they were to be used to attack second-echelon forces such as airfields and ammunition dumps to disrupt enemy operations behind the front lines.

General Accounting Office investigations uncovered fusing, mixing, and detonation problems with Bigeye, which led the U.S. Senate, especially Senator Richard Pryor (D-Ark.), to withhold funding and production go-ahead for the Bigeye bomb. There were two other binary chemical weapons in the U.S. arsenal: a multiple-launch rocket system submunition that never reached the prototype stage, and the 155-millimeter artillery projectiles called M-687, which did reach full-scale production.

The originally proposed deployment of the Bigeye bombs to Europe led to further controversy. The Belgian government nearly fell over the question, and the West German government only approved the deployment in a subministerial forum. A full ministerial approval would have led to a parliamentary debate that the government in Bonn did not want on the heels of the bruising Intermediate Nuclear Force deployment debate over deployment of American nuclear weapons on European soil. The European NATO allies were also disturbed by the adoption of the AirLand battle doctrine, which called for the use of chemical and nuclear weapons to achieve victory over Warsaw Pact forces in the event of war on the inter-German border.

With the signing of the Chemical Weapons Convention, the Pine Buff facility (where Bigeyes were produced) was inspected and then sealed in 1997 by the Organization for the Prohibition of Chemical Weapons, the implementing body established by the convention.

—Gilles Van Nederveen

See also: Binary Chemical Munitions; QL; V-Agent

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BINARY CHEMICAL MUNITIONS

Binary chemical munitions consist of two separate components that by themselves are relatively nontoxic, but when mixed together produce a toxic chemical warfare (CW) agent. Offering advantages particularly in their safer production and handling, binary chemical weapons are more advanced (if not generally superior) to unitary chemical munitions, which simply contain the CW agent (the final toxic chemical product) in the warhead fill. Some binary-type designs may be used in terrorist attacks, with simple designs most likely using more common chemical ingredients (e.g., cyanide).

During the late 1980s, the United States produced a number of binary weapons, including artillery projectiles (containing the nerve agent sarin) and the Bigeye VX nerve agent glide bomb—a ground attack weapon that sprayed agent as it flew over a defined area. Since the signing of the 1993 Chemical Weapons Convention (CWC), all components of binary chemical weapons are undergoing destruction in the United States. It is possible, even likely, that the former Soviet Union also produced binary chemical weapons, including one that produced a novel CW agent called *novichok*. As of this writing, no details on Russian-held binary chemical weapons are found in the open literature. Russia, like other CWC signatories, is enjoined to destroy all of its chemical weapons stockpiles.

The idea of binary chemical munitions is not new. Some concepts for binary chemical weapons were devised during World War II. In one design of an aerial bomb, for example, military chemists separated two components, magnesium arsenide and sulfuric acid, into chambers divided by a partition. When the bomb struck the ground, the partition would be shattered and the chemical components mixed to produce arsine (AsH_3) gas, considered to be a blood agent, that is, it attacks the blood-respiratory system in the body. It does not appear, however, that this chemical ordnance ever found service in any conflict. Another idea considered during the 1940s included the formation of a vesicant (blister agent). For this CW agent, a nontoxic molecule would react with another to form the toxic chemical product, the nitrogen-based blister agent methyl N-(2-chloroethyl)-N-nitrosocarbamate (code named KB-16). As far as it is known, this design was never fully developed into a chemical weapon.

Since the advent of modern chemical warfare, chemical weapons scientists traditionally have considered binary forms of weaponry in order satisfy three basic requirements. The first was to build a chemical weapon that could combine components to produce a constant and prolonged release of toxic chemicals. Another reason for binary designs was to add stability to the chemical components, avoiding the constant problem of shelf life found in unitary chemical munitions. The blister agent mustard and the blood agent hydrocyanic acid (HCN), for example, were notorious during World War I (and dangerous, in the case of HCN) for being unstable during storage. Finally, from the production base to logistics on the field, binary chemical munitions were designed to produce a weapon that was safer and easier to handle than highly toxic unitary weapons. This has become especially important since the discovery and development of modern nerve agents. One of the most important benefits of producing nontoxic binary components is that these can be manufactured at chemical production plants without a special safety process and control system. Furthermore, when the two parts are stored in different locations (as is done in the United States with its binary artillery shells), the chance of catastrophic accidents during handling is less likely with binary weapons than with unitary ones.

Maritime traditions are replete with exacting standards of safety. It should not be surprising that the hazards involved in transport and handling of chemical weapons were of special concern to the U.S. Navy. During the mid-1960s, the U.S. Navy had patented a design for a binary chemical weapon utilizing two chemicals—one liquid and one solid—that would react to form a toxic CW agent. This was probably the prototype for the VX Bigeye bomb that was developed two decades later. In 1969, the U.S. Navy submitted requests for proposals to defense firms that included research and development of "a chemical cluster weapon capable of mixing and reacting two non-toxic chemicals to generate toxic agent within the cluster payloads" (SIPRI, p. 307). This was a requirement for a binary chemical munition, probably involving the production of nerve agents such as sarin (GB) or soman (GD). By 1972, the U.S. military had been able to build a prototype of a binary chemical weapon for use in land-based artillery. This would later become M-687, the 155-millimeter howitzer projectile.

During the Cold War, the U.S. approach to binary chemical ordnance focused on two types: binary sarin (for an artillery projectile) and VX (Bigeye) agents. The M-687 projectile produced sarin by mixing difluoromethylphosphonate (or difluor) and isopropyl alcohol. After the weapon was fired, the membrane separating the component chemicals would be shattered by the force of gravity. Now spinning at thousands of revolutions per minute, the weapon's rotation in flight facilitated the mixing of the binary components to form sarin. When the projectile neared its target, a special fuse mechanism ensured efficient dissemination of the agent through the back of the projectile. One component of the M-687 projectiles was stored in Umatilla, Oregon, and the other was held in storage at Pine Bluff, Arkansas. All are soon to be destroyed pursuant to the CWC.

During the 1980s, the Ronald Reagan administration revamped the U.S. military's offensive chemical weapons arsenal as a means to better counter Warsaw Pact forces. In part because of its relatively simple design, significant numbers of the M-687 howitzer binary chemical round were produced until 1991, when offensive chemical weapons were renounced by the George H.W. Bush administration.

The VX Bigeye glide bomb, developed under the auspices of the U.S. Navy, was intended to spray VX from an aerial munition that would glide over the target. Two relatively nontoxic compounds, sulfur and a chemical code-named QL , would combine to form VX within the bomb itself. Although a working prototype was built, the project was plagued with technical problems, not the least of which was a tendency for the munition to burst prematurely because of expanding internal gases. The BLU-80/Bigeye was designed to deliver some 180 pounds of VX nerve agent.

Although binary chemical weapons clearly offer many advantages, they also have their drawbacks. The design used in the Bigeye VX bomb was clearly difficult and complex to engineer, and few countries can afford the cost of producing large numbers of this type of ordnance. Also, as one would expect in any synthesis, the chemical reaction in a binary system is not instantaneous. Furthermore, portions of the round consist of various non-CW chemicals, including some containing fluorine, which generate distinctive odors that could be quickly detected by an enemy.

Other Designs

Because of its ability to fire a large and redundant number of volleys, the multiple-launch rocket system (MLRS) has long been considered one of the more effective delivery platforms to increase the concentration of chemical warfare agent on a given target. The U.S. Army had produced both sarin and VX unitary warheads for the M55 rocket used by the MLRS.

A binary design that only made it to the prototype stage was for a so-called intermediate-volatile nerve agent munition for the MLRS. Although exact details are not available, it is possible that the binary components would have produced a nerve agent that had moderate persistence, perhaps soman (GD) or cyclosarin (GF). When using rockets in a direct-fire weapon like the MLRS—as opposed to a shell with a ballistic trajectory—one would have to consider the target and trajectory, allowing for enough time for components to fully react.

Because of the ongoing interest by the United States in refurbishing its chemical arsenal, combined with the massive Soviet military threat in the 1980s—or perhaps a combination of the two—China began to study the production of binary chemical munitions for its People's Liberation Army. Whether or not these munitions went beyond the blueprint stage is unknown. One diagram found in Chinese military writings on chemical warfare depicts what appears to be a rough design for a binary warhead, perhaps a sketch of the HY-1 (Hai-Ying) cruise missile (based on the original Soviet Styx). It is not certain if such a design would be effective, or if its aerodynamics would affect its trajectory. Chinese publications also have shown a design for a putative binary rocket for their MLRS that could be based on a real prototype. It features the binary components being mixed inside the rocket warhead, and explosive charges along the center being used to disperse the nerve agent.

Having signed and ratified the 1993 Chemical Weapons Convention (CWC), China has vowed to declare and destroy any past or remaining chemical weapons in their inventories. Little is known about past or present Chinese production or deployment of binary chemical weapons. Anecdotal evidence suggests that China considered producing binary chemical weapons, including those for artillery rockets, but considered the associated per unit costs to be exorbitantly high.

Western intelligence has long suspected that the former Soviet Union developed binary chemical weapons. It is likely that Soviet chemical weapons designers developed designs for sarin binary and perhaps VX nerve agent munitions. Following the breakup of the Soviet Union in the early 1990s, an intriguing story that came to light was the research into novel CW agents conducted by Soviet chemical weapons scientists. These included *novichok* (Russian for *newcomer*) chemical compounds, some being up to ten times more toxic than VX nerve agent. According to Russian dissident scientists, novichok agents were to be used in binary weapons. The usual means of treating nerve agent casualties would not be effective against this highly toxic chemical. Details on this and other novel CW agents reportedly developed in the former Soviet Union are still classified.

Terrorists may also utilize the basic concept of binary chemical systems for sabotage or even large-scale attacks. In 1995, immediately following the sarin nerve agent attack on the Tokyo subway by the Japanese cult Aum Shinrikyo, cyanide binary devices were discovered in subway restrooms. Consisting of two containers, one holding solid cyanide salt and the other a dilute acid solution, a crude timer was to have combined the components to form hydrocyanic acid (HCN) gas. Fortunately, these chemical devices were deactivated before they could do any harm. Another design found in the open literature proposes to mix two relatively nontoxic compounds that would form phosgene gas, a toxic lung irritant. It is uncertain if such a system could create sufficient concentrations of phosgene gas to cause death or injury.

—*Eric A. Croddy*

See also: Bigeye; Difluor; QL; V-Agents

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BIOLOGICAL AND TOXIN WEAPONS CONVENTION (BTWC)

The 1972 Biological and Toxin Weapons Convention (BTWC—often referred to as the Biological Weapons Convention, or BWC) prohibits the development, production, and stockpiling of biological weapons. There are currently 147 countries that are party to the BTWC. Although not explicitly stated in its preamble, by inference the BTWC prohibits the use of microbial or other biological agents, or toxins, whatever their origin or method of production. Unlike the Chemical Weapons Convention (signed in 1993), however, as of 2004, the BTWC has no verification protocol—that is, the BTWC has no set rules or guidelines to verify compliance by its members. Although its current status as a "toothless" disarmament treaty does not make its obligations any less binding upon its parties, the BTWC is little more than a gentleman's agreement. A verification protocol for the BTWC is not likely to be concluded by the end of the first decade of the twenty-first century. Because it has thus far lacked verification provisions, confidence-building measures (CBMs) were adopted during the second BTWC Review Conference in 1986, and parties to the Convention are now submitting BW-related reports on an annual basis to the United Nations. After failed attempts to arrive at an acceptable protocol, the United States and other treaty members are engaging in efforts to enhance the effectiveness of the BTWC with biosecurity initiatives.

Background: CBW History

The first effort to prohibit the use of biological weapons—albeit with important loopholes and exceptions—can be found in the 1925 Geneva Protocol, sometimes called the Gas Protocol. Its full title was Geneva Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous, or Other Gases, and of Bacteriological Methods of Warfare. The inclusion of the term *bacteriological methods of warfare* was made nearly at the last minute by the suggestion of the Polish delegate. (Viruses were poorly understood in 1925, but they certainly would have been included in the title, had they been better understood at the time.) As in the case of chemical weapons, the Geneva Protocol of 1925 only prohibited the first use of such weapons against other parties to the treaty, and not the development, production and stockpiling of such weapons.

Prior to the 1925 Protocol, there had been acts of sabotage in World War I that used bacteria. The German-American agent Anton Dilger conducted a number of attacks on Allied horses and pack mules from 1915–1916, using the causative agents of glanders (*Burkholderia mallei*) and anthrax (*Bacillus anthracis*). Working from a makeshift laboratory in Washington, D.C., Dilger hired other agents—including longshoremen—to infect animals in their stockades along ports in the eastern United States. These acts of biological warfare (BW), however, were barely noticed by Allied authorities.

During the 1930s, biological weapons were still very much an unknown quantity. In December 1932, a report from the Special Committee on Chemical, Incendiary, and Bacterial Weapons—for the Conference for the Limitation and Reduction of Armaments—stated: "Chemical warfare is known from actual experience; bacteriological warfare, on the other hand, is a hypothesis. Nor are there any results of laboratory experiments on which knowledge can be based. The behavior of pathogenic microbes intentionally transported from the laboratory to natural media is practically unknown to us. It must nevertheless be admitted that such warfare is possible" (Fradkin, pp. 58–59). The Conference also predicted the future conundrum faced by arms control and disarmament in the realm of biological weaponry:

> We are not at present in a position to subject bacteriological research to effective supervision. Virulent bacteria, such as might cause epidemics, are to be found in all bacteriological laboratories (both public and private), and also in hospitals treating contagious diseases. There can be no question of hindering the progress of medical bacteriology, the objects of which are humanitarian (the preparation of sera, vaccines, etc.), by supervising and restricting experiments with virulent cultures. Such supervision, moreover, would never be complete and therefore always ineffective. (Fradkin, p. 59)

As military aviation made rapid advances during the early twentieth century, public and official concern about the threat posed by incendiary bombs or toxic biological and chemical mists increased. Elvira K. Fradkin, in a 1934 treatise called *The Air Menace and the Answer,* described how biological agents could rain death from the skies: "An airplane could carry enough of the botulinus toxin to destroy every living thing in the world if administration of the toxin were as simple a process as production and transportation" (Fradkin, p. 57). And although never quite certain of what threat existed from germ warfare, in 1938, the British scientist John Burdon Sanderson Haldane warned that yellow fever could be utilized as a biological weapon. A year later, Imperial Japanese agents visited the Rockefeller Institute in the United States in an attempt to acquire cultures of yellow fever virus. As yellow fever was not a disease endemic to the Far East, these surreptitious inquiries aroused suspicions by Western intelligence. These reports of Japanese efforts to obtain and develop potential BW agents—as well as (often spurious) intelligence indicating that Nazi Germany had an interest in biological weapons—encouraged the Allies to initiate their own BW programs.

During World War II, the United States, Canada, and the United Kingdom initiated substantial programs for BW defense and offense, including the production of virulent organisms such as anthrax spores. Although committed not to use such weapons unless for retaliation in kind, Presidents Roosevelt and Truman continued offensive research and development of biological weapons. North Korea and the People's Republic of China alleged that the United States used biological weapons during the Korean War (1951–1953). These allegations are not supported by any credible evidence.

Throughout the Cold War and until renouncing biological weapons in 1969, the United States tested and weaponized several offensive BW agents, including *Brucella,* anthrax, tularemia, staphylococcal enterotoxin B, and anticrop agents. Although U.S. military commanders were usually somewhat skeptical of their utility, American BW scientists were confident by the 1960s that their validated biological delivery systems could be effective in shutting down enemy ports, or indeed in bringing a whole country to its knees by the use of debilitating viruses, bacteria, or toxins.

Until the late 1960s, for much of the U.S. public, the idea of using chemical and biological agents was not particularly controversial, or at least it appeared that way. The use of chemical herbicides (including Agent Orange) and CS tear gas during the Vietnam War, however, led to protests against the perception that chemical warfare (CW) agents were being employed by the United States in that conflict. In March 1968, some 6,000 sheep were killed near Dugway Proving Ground, Utah. Their owner claimed that the U.S. Army was responsible when aircraft dropped VX nerve agent during training runs near Skull Valley, Utah. Although the U.S. Army paid the farmer $1 million in restitution, it did not admit to being culpable. Still, the impact of this incident—and ongoing operations by the United States in destroying obsolete chemical weapons by dumping them into the ocean—led to public questions concerning U.S. offensive CBW policies. In response, the Nixon administration reviewed the U.S. position with regard to both CW and BW in May 1969. Two months later, a chemical spill on a U.S. military base in Okinawa, Japan, exposed twenty-four people (including one civilian) to sarin nerve agent. Protests erupted in Japan as a result, and further revelations that U.S. chemical weapons were stored in West Germany added more fuel to the controversy.

Makings of a Convention

As the public outcry in the United States against chemical and biological weapons grew, the United Kingdom brought forth a proposal on July 10, 1969, to the UN's Eighteen-Nation Disarmament Committee that would ban production, development, and stockpiling of biological weapons. In 1968, this committee had considered a comprehensive ban on all forms of chemical and biological of warfare. At that time, however, Western countries such as the United Kingdom did not believe that BW would be as important as the immediate threat posed by chemical weapons, and they preferred that CW and BW be treated separately. In 1969, President Nixon made the decision to renounce biological warfare—specifically the use of disease-causing organisms—mostly because of their perceived technical problems, but also because enemies could plausibly threaten large populated cities in the United States. By supporting biological weapons disarmament, Nixon also hoped that this decision would improve the public image of his administration and the United States. After some further internal debate by 1970, biological toxins (not just disease-causing pathogens) were included in the unilateral renunciation of BW by the United States.

In the years 1970 and 1971, negotiations in Geneva over a biological and toxin weapons treaty had been making little progress for a number of reasons, mostly having to do with an insistence by the Soviet Union that chemical weapons also be included in the treaty. The Soviets finally relented on this point, however, and the final version of the BTWC was approved on September 28, 1971, opened for signature in April 1972, and put into force in March 1975.

Five years following the treaty's entry into force, the first Review Conference of the BTWC was held in March 1980. Intense discussions at this conference were spurred in part by the advances already made in genetic engineering, as well as by the increased military interest around the world in the biological sciences. Two controversies were brought forward during this time: the Sverdlovsk anthrax outbreak in 1979 and U.S. allegations of yellow rain (T-2 mycotoxin) being used by Soviet client states in the Middle East and southeast Asia. Reports concerning the Sverdlovsk outbreak appeared at the same time as the first Review Conference took place. Not surprisingly, the then-suspected (now confirmed) release of a biological warfare agent (anthrax spores) raised great concerns, not only about Soviet BW programs but also about the implications of future verification, inspections, and BTWC compliance.

During the second Review Conference in 1986, four important confidence-building measures (CBMs) were established in order to increase the level of trust among signatories and improve transparency: (1) Annual provision by signatories of data on high-containment facilities designed for work on dangerous biological materials; (2) Annual notification to signatories of outbreaks of unusual diseases; (3) Encouragement of publication of results of biological research related to the BW convention; and (4) Promotion of contact between scientists engaged in research, including exchanges of staff for joint research.

The overall response to the CBMs was tepid, with fewer than forty countries reporting regularly on an annual basis since the 1986 review. Most developing nations either did not send declarations, or their declarations were incomplete. Although China and the Soviet Union did supply information detailing their BW-related programs, by 1991 only 40 signatories out of 117 had established their own domestic legislation for implementing proper declarations, and only 70 (out of 135) had done so by 1996.

At the 1991 review, considerations for strengthening the BTWC were inspired by the recent Gulf War. Several proposals were made, including a measure to extend Article 1 to cover BW agents against plants and animals. CBMs added to the convention included:

- Declaration of data on national biological defense programs and facilities, as well as high-containment facilities
- Better definition of an unusual outbreak of disease
- Emphasis on publication of results
- Promotion and publicizing of contacts between staff involved in BW defense
- Declaration of legislation and other regulations to implement the provisions of the Convention and to control the export of BW agents
- Declaration of past activities in offensive or defensive biological programs since January 1, 1946
- Declaration of production facilities for vaccines against human diseases

To develop the technical means to verify compliance with the BTWC, the Ad Hoc Group of Government Experts (**Ver**ification **Ex**perts or VEREX) was established at the 1991 review. Within the two categories of on-site and off-site inspection measures, VEREX determined twenty-one means of verifying BTWC compliance.

Additional meetings of the VEREX group were held in Geneva between March 1992 and September 1993, resulting in a final report to the BTWC parties. Though VEREX was able to conclude that at least some combination of the measures listed above was promising, it did recognize that the dual-use nature of BW-related technology, basic equipment, and starting materials made verification of the convention problematic. During the Ad Hoc Group meetings in 1994, additional discussions called for measures to strengthen the BTWC, suggesting that challenge inspections and peaceful transfer of biotechnology should also be included. Later, the Ad Hoc Group held three meetings in 1995, two substantive meetings in 1996, and other meetings during 1997–1998. The eleventh session (June 22 to July 10, 1998) involving the fifty-two-nation Ad Hoc Group concluded with a 250-page "rolling text," which contained about 3,000 reservations from individual parties.

Current Status

In late 2001, BTWC protocol negotiations came to an impasse. In rejecting the last iteration of the draft protocol text, U.S. Undersecretary of State John Bolton said on November 19, 2001: "The draft protocol that was under negotiation for the past seven years is dead in our view. Dead, and is not going to be resurrected. It has proven to be a blind alley" (U.S. Department of State, 2001). This pronouncement not only crystallized U.S. officials' opposition to what they saw as a seriously deficient protocol; it also led to widespread doubt that little, if anything, would be accomplished at the fifth Review Conference. Upon concluding the November 2002 review, however, the parties were able to agree on some substantive issues and to plot a course for annual meetings before the next conference in 2006. In summary, the parties agreed to the following scheduled agenda: in 2003, domestic legislative initiatives and rules to govern the safe use and transfer of dangerous pathogens would be considered; in 2004, increased efforts for global disease surveillance and better mechanisms to evaluate the cause of disease outbreaks would be discussed; and in 2005, an agreed protocol for scientists and researchers conducting research relevant to the BTWC would be negotiated.

Although it seems naïve to suggest that criminalizing biological weapons will dissuade individuals or governments determined to acquire them, many believe that making the possession or use of biological weapons a universal crime could further biological weapons disarmament.

—Eric A. Croddy

See also: Australia Group; Chemical Weapons Convention; Geneva Protocol

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BIOLOGICAL TERRORISM: EARLY WARNING VIA THE INTERNET

The use of a biological weapon can be recognized by the appearance of a deadly pathogen or toxin in an unexpected place or an unexpected season, or by the appearance of a previously unknown agent. The key to containing the resulting outbreak of disease is rapid detection and reporting. In recent years, outbreaks of the previously unknown viruses Hendra, Nipah, and SARS (severe acute respiratory syndrome) in Asia and of anthrax, West Nile, and monkey pox viruses in the United States have met the above criteria. Although only the anthrax that appeared in the U.S. postal system turned out to be a terrorist attack, the Internet played a crucial role in providing early warning of many of these disease outbreaks.

The free, independent, public Internet network ProMED (Program for Monitoring Emerging Diseases) was launched by the Federation of American Scientists in 1994 to give early warning of bioterror attacks. It is now operated by ISID (the International Society for Infectious Diseases). On November 18, 2001, Dr. D. A. Henderson, director of the Office of Public Health Preparedness of the U.S. Department of Health and Human Services, wrote, "ProMED-mail with CNN was our main source of information through most of the recent anthrax outbreak!" (Henderson, 2001).

Plague is considered to be a potential biological weapon. On June 22, 2003, ProMED sent a newswire report of an outbreak of bubonic plague in Algeria by e-mail to its 30,000 subscribers in 150 countries, a report that was also seen by thousands more who accessed ProMED's website. Two days later, the World Health Organization (WHO) in Geneva posted an alert on its website after it obtained clearance from the country concerned to publish the report. If this had been a terrorist attack—Algeria has suffered from a number of nonbiological terrorist attacks in the past—the extra 48 hours' advance warning could have made a vital difference in terms of alerting physicians to look for suspicious symptoms in persons from the area, perhaps as they carried the disease to other countries.

Smallpox virus is another agent that has been listed as a potential bioweapon. All cases of suspicious smallpox-like rashes must be investigated and immediately reported to local health authorities and WHO. On June 7, 2003, the U.S. Centers for Disease Control and Prevention (CDC) issued a press release on its website: About seventeen cases of pox-like rash had occurred in people living in the western United States who had come into contact with sick pet prairie dogs. Onset of the first cases had been in early May 2003. The diagnosis was monkey pox, a disease never before seen in the Americas, and the source was eventually traced not to bioterrorism, but to infected Gambian giant rats from Africa. The rats, sold as pets, had been in contact with the prairie dogs in pet stores and at pet sales. As a result of this public announcement, fifty-four more cases were identified and 3 more states were found to be involved in the outbreak of monkey pox.

On June 23, 2003, a report appeared on the Internet of an outbreak of a pox-like disease in a remote area of the Republic of the Congo (Brazzaville). The report was sent in by a missionary doctor working in the region. Patient specimens were sent to the CDC, which diagnosed them to be cases of monkey pox, not smallpox. That was the first public notice of these cases, which had reportedly been occurring since mid-April 2003. Public health officials across the globe need to be informed rapidly of all such cases so that smallpox can be ruled out, or so that vaccination can be provided if smallpox does reemerge anywhere in the world.

On February 10, 2003, both WHO and ProMED received e-mail queries about an outbreak of a virulent form of pneumonia in Guangdong, China, subsequently named SARS (severe acute respiratory syndrome). WHO immediately asked for official confirmation, forcing the Chinese government to admit to the outbreak, but clearance for WHO to issue a public warning took 48 hours to obtain. ProMED is an independent network, so it was able to post the news by e-mail and on its website immediately. Once again, if this had been a terrorist attack, advance warning could have made a crucial difference in terms of response and containment.

The real importance of this episode was that individuals, not governments or public health officials, informed the world health authority and a public Internet list directly about a deadly outbreak.

It was later discovered that cases of SARS had been noted at least as far back as November 2002, and news about them had been circulating on the Chinese internet, so the early warning had been out there for anyone who knew where to look and could read Chinese. Health Canada's GPHIN (Global Public Health Intelligence Network) had distributed reports of outbreaks in the original Chinese with English headlines to a closed subscriber list. ProMED is developing a Chinese language website and e-mail list, and translations will feed into the open English language list.

Internet reporting had earlier helped to uncover another new virus in Asia. In October 1998, fatal cases of encephalitis began to be seen in parts of peninsular Malaysia where pig farming was practiced. The outbreak was initially attributed to Japanese encephalitis virus (JEV), but on January 17, 1999, a virologist posted a message on the Internet pointing out that the profile of the cases did not fit that of JEV infection. List moderators continued to query the official diagnosis thereafter, and two months later, the Malaysian government officially declared that a new virus was involved, which was named Nipah virus.

By contrast, the arrival of West Nile virus in the United States was not uncovered on the Internet. When crows were found dead in the Bronx Zoo in New York City in 1999, nobody thought to send a report on them to an Internet list with a wide, interdisciplinary readership such as ProMED. Such an alert might have alerted investigators to a possible connection between the avian deaths and the concurrent epidemic of human encephalitis in New York City.

Agroterrorism Warnings

Agroterrorism, or terrorism involving attacks on livestock or crops of major food or economic value, is now recognized as a potential threat. The huge and costly outbreak of Newcastle disease in poultry in four western and southern U.S. states, which was recognized in late 2002, probably did not enter the country through the commercial poultry trade, but via imported fighting cocks kept in private back yards. On the same day that the World Animal Health Organization (OIE is its French acronym) posted news of the initial outbreak on its website, ProMED copied it by e-mail to its 20,000 U.S. subscribers, reaching a much broader audience. This incident suggests that a comprehensive early warning system for bioterrorism events must also cover animal and plant diseases. Early warning is important because it enables owners to look for symptoms in their animals and to take precautions. A warning network can also raise suspicion in the minds of veterinarians treating sick livestock.

Brazil is the world's largest orange producer and exporter of frozen concentrated orange juice, generating annual revenues of about $5 billion. The Brazil orange crop is being progressively infected by citrus sudden death (CSD) disease, which had by 2003 spread into the state of Sao Paulo, an area that accounts for 85 percent of Brazil's 280 million trees. There is no cure for CSD; trees simply have to be replaced by planting resistant varieties, which take years to come into production. An attack on an important food or export crop such as oranges would therefore cause economic havoc and damage national food supplies; hence, important outbreaks of plant pathogens need to be reported widely in a timely manner. Here, there is room for improvement. The European and Mediterranean Plant Protection Organization (EPPO) sends out a monthly report by e-mail, but other regional plant protection organizations have yet to connect their members through the Internet. ProMED picks up food crop reports from the newswires and its own subscribers, but it does not cover economically important nonfood crops.

Technical Aspects

Web spiders and bots have been created by a number of organizations to comb the Internet for reports of outbreaks, using keywords. One of them is GPHIN, operated by Health Canada, whose output is made available to WHO but is otherwise closed to the public. There also are a number of similarly constructed military networks. The University of Guelph, Canada, operates networks on food safety and agriculture topics, FSNet and AgNet, which are open for paid subscription. San Diego State University hosts MiTAP (MITRE Text and Audio Processing), developed by defense contractors but open to the public. MiTAP monitors infectious disease outbreaks and other global threats. Hundreds of information sources are automatically captured, filtered, summarized, and categorized into searchable newsgroups based on disease, region, information sources, person, and organization. Critical information is automatically extracted and tagged to facilitate browsing and sorting, and an information retrieval engine supports source-specific, full-text keyword searches. The system processes thousands of articles daily, delivering up-to-date information to more than 600 users. The capability to handle foreign languages is being developed. MiTAP complements GPHIN and ProMED in the outbreak early warning field, but both MiTAP and ProMED face serious funding problems.

MiTAP requires the user to visit its site and browse, whereas ProMED, in addition to posting outbreak reports on its site, sends reports by e-mail so that subscribers get them as soon as they check their e-mail. ProMED is presently the only independent, free to the user, publicly accessible, global network that gives early warning of outbreaks of human, animal, and plant diseases that have the potential to impact international trade and travel. It is unique in that it receives reports not only from the major newswires, but also from local media; from its subscribers (through forwarding of new items); and from physicians, veterinarians, researchers, hospitals, and laboratories working with actual disease outbreaks. For instance, ProMED had contact with a physician in mainland China during the SARS epidemic, who was able to put the official reports about SARS in context. It received clinical details of the smallpox-like cases in the Republic of the Congo from the doctor who examined cases there. It received news directly from a hospital in Germany concerning a case of Lassa fever, a hemorrhagic disease that usually occurs in Nigeria. It has also received reports on outbreaks in Australia from chief veterinary officers there, including the first report of Japanese encephalitis virus from that country. All reports posted on ProMED are prescreened by a panel of moderators who are experts in their particular specialties, so that hoaxes and questionable reports are not posted to the list.

Thus, ProMED provides an important complement to official outbreak reporting networks such as those of the WHO and CDC, with the advantage that ProMED is unconstrained by the need to receive official clearance from the countries involved. In addition, ProMED covers animal and crop plant outbreaks, which WHO and CDC do not. But it is also evident that even a global network cannot catch every outbreak of potential importance. It needs to be supplemented by national networks, preferably with the same independence of operation. ProMED-style networks have already been set up in Brazil and the Netherlands, and one will soon be set up in South Korea. Using subscribers' own computers, university servers, and part-time staff, these national networks are highly cost-effective.

The examples given here show that the Internet has repeatedly proved its worth as a medium for early warning about outbreaks of disease that could have been caused deliberately.

—Jack Woodall

See also: Agroterrorism (Agricultural Biological Warfare); Bioterrorism

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BIOLOGICAL WARFARE

Biological warfare (BW) refers to the use of living organisms, or of toxins produced by living organisms, as weapons against humans, animals, or plants. In the modern parlance, there is usually a distinction made between BW and bioterrorism, the latter referring to the terrorist use of BW agents and weapons. Although the effects of a bioterrorist incident could have far-reaching ramifications, generally speaking these would be smaller in scale and would probably employ less sophisticated technology than in state-level BW programs. BW agents have already been utilized in modern-day acts of terrorism, albeit with a relatively small impact in terms of total casualties (including both injuries and deaths). For example, five people died and twelve others were infected in 2001 by anthrax spores (*Bacillus anthracis*) that were mailed through the U.S. postal system by an unknown perpetrator.

In the military sense of BW, however, one would expect to have large numbers of casualties (in the thousands and even millions) caused by the large-scale delivery of BW agents suited for military (counterforce) or civilian (countervalue) targets. In fact, next to nuclear weaponry, biological weapons pose the greatest threat in terms of causing mass casualties. The major differences between nuclear warfare and BW include the lack of persistent contamination following the use of biological weaponry (with some important exceptions) and the fact that biological munitions do not damage physical structures (such as buildings or other infrastructure). Biological weapons might therefore be more accurately referred to as mass casualty weapons instead of weapons of mass destruction (WMD).

Before renouncing the use of BW in 1969, the United States possessed a significant stockpile of biological weapons systems. The Soviet Union had at least a rudimentary program since the 1920s, and it continued to develop BW agents and delivery devices long after pledging not to do so (from about 1975 to 1990). The Soviet Union researched, developed, and produced large quantities of potent BW agents including anthrax, smallpox, and plague for loading onto warheads that could hit U.S.-based targets (using intercontinental ballistic missiles). During the Cold War, the two superpowers had the capability of inflicting hundreds of thousands of biological casualties with the use of such weapons. Both countries, as well as many others who are party to the 1972 Biological and Toxin Weapons Convention (BTWC), have since agreed to ban the possession, research, and development of offensive biological weapons. But there exists today the possibility that other states could develop BW programs that could attain or even exceed the level of devastating potential once held solely by the United States and the Soviet Union.

Biological Warfare in History

There are historical cases of armies using infectious disease as a weapon going back at least 600 years. One incident was the siege of the city of Kaffa by Mongol forces in 1346 C.E. During this campaign, bubonic plague had already infected and killed many of the Mongol (Tartar) troops, and it was rapidly being spread by the ubiquitous presence of rats and their associated fleas. In a clever if somewhat desperate move, the leader of the Mongols decided to hurl his own dead soldiers over the walls into Kaffa (presumably using siege engines). The intent was apparently to spread disease among the European traders who had made Kaffa their refuge (Karlen, p. 87). It is unclear, however, if this technique really worked (Wheelis, p. 13). Although the tactic seemed to show the deliberate use of a BW agent, one should note that this would not have been an effective means to transmit plague. In the case of bubonic plague, the causative bacteria (*Yersinia pestis*) are spread by fleas that will only feed upon live hosts, and so it not likely that plague could have been disseminated by using corpses as a delivery system. The presence of rats, and the fleas that spread the disease, however, ensured that a pool of host animals brought plague throughout Europe. As a classic text on disease vectors noted, "The rat, as transported in commerce, constitutes the chief means of spreading the diseases [i.e., plague], the infection being carried from rat to rat by means of rat fleas. For this reason plague may appear in a city far removed from the original focus of infection" (Herms, p. 424). This was the likely and ultimate source of disease transmission, not human cadavers.

Similarly, there was clear intent to spread disease as a means of warfare during the French and Indian War (1754–1767) (Fenn, p. A11). During the wars against Native Americans, British military advisors in the New World plotted to use smallpox in order to "Bring about the Total Extirpation of those Indian Nations" (d'Errico). The colonial armies apparently proceeded to obtain blankets from smallpox hospitals and to give these to the native tribes. However, as in the case of plague during the siege of Kaffa (see above), it is not clear if the methods used here resulted in significantly higher rates of infection among the native tribes in the Americas than by the natural spread of smallpox. After all, millions of indigenous peoples had already died from the natural spread of smallpox following the arrival of the first Europeans to the New World. Also, the virus (*Variola major*) is not known to be transmitted by using bedding or linens that had contact with previous smallpox victims, but it is highly transmissible from aerosols and infectious droplets from active infections.

These premodern examples of BW occurred in an era when infectious disease was not well understood. Until the advent of modern microbiology, particularly the groundbreaking work of Louis Pasteur and others in the late nineteenth century, the conception of disease was usually linked to "foul vapors" or miasmas that mysteriously caused epidemics. (The name *malaria,* for example, comes from the Italian meaning *bad air.*) The idea that a germ could be the source of deadly disease took considerable time to find widespread acceptance. Only in the nineteenth and twentieth centuries were scientists able to isolate the disease-causing microorganisms and to confirm the identity of a pathogen. Thus, the historical references to BW are of relevance only in that there was the deliberate use of disease as a weapon.

By the 1930s, however, a number of scientists and military thinkers had begun to seriously consider the potential threat from biological weapons. For example, in 1925, a Polish military officer persuaded the conference for the Geneva Protocol (or Gas Protocol) of that year to include a ban on "bacteriological" weapons in addition to the prohibition of chemical weaponry. And although the threat of BW seemed real, the science and application of biological weapons still was very much terra incognita. We know now that the only practical and effective means of conducting offensive BW depends primarily upon the use of aerosols, which are infectious particles that can be spread through the air and inhaled into the lungs to cause disease (*see* Aerosol). In the 1930s, however, the idea that disease could be spread through the air still had its critics in the scientific community. At Geneva, Switzerland, during negotiations on limiting armaments, a Special Committee on Chemical, Incendiary, and Bacterial Weapons wrote the following in December 1932:

> The problem of bacteriological warfare is entirely different from that of chemical warfare. Chemical warfare is known from actual experience [e.g., World War I]; bacteriological warfare, on the other hand, is a hypothesis. Nor are there any results of laboratory experiments on which knowledge can be based. The behavior of pathogenic microbes intentionally transported from the laboratory to natural media is practically unknown to us. It must nevertheless be admitted that such warfare is possible. Furthermore, we can only imagine what it would represent and how it could be prepared, and deduce from such suppositions possible methods of defense. (Fradkin, pp. 58–59)

During the 1920s and 1930s, other voices such as that of the British scientist J. B. S. Haldane warned against the potential of biological weapons. Haldane suggested that yellow fever could be utilized as such a weapon. Indeed, in 1939, Japanese agents attempted to acquire yellow fever virus from the Rockefeller Institute in New York, but they failed in their somewhat awkward attempts to purchase the virus. (Yellow fever is not endemic to Asia, and thus Japan's interest in the disease appeared quite suspicious to U.S. intelligence agencies.) This incident set off a warning for the United States security apparatus, particularly as American involvement in war was looming on both the European and Pacific fronts. As a consequence, the Allies began to collaborate on developing, and defending against, offensive BW capabilities.

Although Germany had little in the way of an ongoing BW program, the Allies could not be certain of that at the time, and they therefore planned for the worst. As for Japan, it had already begun an active program in China, from about 1938 until the end of World War II. In gruesome experiments that sometimes included live vivisection of humans, the

Japanese scientists in Unit 731 and related detachments of its hygiene and veterinary services researched plague, anthrax, gas gangrene, and other diseases. The Japanese military scientists also developed weapons, including bombs that delivered plague bacteria using the flea as a vector (transmitting organism).

During World War II, the United States, Britain, and Canada jointly researched antihuman, as well as antiagricultural, BW agents. Although much of the research began as a means to defend against possible attack, bombs filled with anthrax spores were produced and tested on Gruinard Island (off the coast of Scotland). But in the European theater, no biological (or chemical) weapons were used. On D-Day in June 1944, the Allies had prepared enough botulinum vaccine (toxoid) to administer to all of the troops getting ready to land in Normandy. This massive toxoid program was begun based on faulty intelligence that the German military planned to use botulinum toxin against an Allied invasion.

During the Cold War (1947–1991), the United States developed a number of offensive biological weapons, the first being a bacterial munition loaded with *Brucella suis* in the early 1950s. Anthrax, tularemia, Q-fever, and Venezuelan equine encephalitis (VEE) were also researched and produced for delivery against Soviet or Cuban targets, and anticrop agents were stockpiled for use on the grain fields in Ukraine and China.

During this period, the Soviet Union also pursued biological weapons development, but their biological sciences were held back by poor technology and a political climate that wreaked havoc on their scientific community. When President Richard M. Nixon decided that the United States would unilaterally disavow offensive biological warfare in 1969, the Soviet Union had just started to come out of its relative dark ages in terms of modern genetics as well as other biological disciplines. To help catch up to the West, the U.S.S.R. embarked on a massive biotechnological initiative that was primarily touted for being the foundation for developing strategic biological weapons. The Soviet Union developed many of the same BW agents as the United States, including anthrax, tularemia, and antiagricultural biological weapons. The Soviet Biopreparat complex also researched and developed a plague weapon, as well as producing tons of smallpox virus for use in the event of an all-out war with the United States and its allies. Most Russian research in offensive BW essentially ended under the Boris Yeltsin administration, although some Western security analysts believe that such work continues even today, albeit on a much more limited scale.

Delivery of BW Agents: Basic Principles of Biological Weapons and Aerosols

The main operating principle of biological weaponry is the use of infectious aerosols. This is considered the most efficient method of delivering BW agents to infect large numbers of people. In a less likely scenario, however, insects could be bred near a living host (say, a rat) infected with disease-causing organisms, such as plague bacteria (*Yersinia pestis*). During World War II, for example, Japanese BW scientists used fleas that were raised alongside plague-infested rats. As fleas collect plague bacteria in their foregut (proventriculus), under certain conditions these organisms form a blockage of their digestive tract. Desperate for nutrition, when these hungry fleas find another host (such as a human), a flea discharges the mass of bacteria into the opening of its bite, causing an infection. In nature, animal and human diseases caused by bacteria are often due to the contamination of food and water, as well as transmission by arthropods (vectors). The bacterium that causes tularemia or rabbit fever (*Francisella tularensis*), for example, can sometimes infect humans through ticks carrying the pathogen; the organism is transmitted through the tick's bite. But the use of vectors (or of contamination of food and water) to spread disease on a large scale is not considered a significant BW threat. It is not an efficient mode of delivery to cover large targeted areas, and on the defensive side of the ledger, there are now a number of insecticides available to combat mosquitoes and other disease-carrying insects.

Biological weapons must therefore rely on aerosols for effective dissemination. Nearly all known BW agents must be produced and delivered in very small particles, ranging from about 1–10 microns in average diameter. (The one exception is the dermally active toxin T-2 and related trichothecene mycotoxins, although these toxins would also be effective when delivered as aerosols.) Particles ranging between 1–10 microns are more likely to lodge themselves into the very small alveoli, the tiny air sacs in the lung where oxygen and carbon dioxide are exchanged during respiration. Here, the alveolar wall is only about 2 microns thick, and pathogens can pass into the bloodstream. Particles larger than 10 microns (0.010 millimeters) are more apt to be caught in the upper respiratory tree and in the nasal passages. Many of these larger particles, instead of starting an infection, are instead brought back up and out by cilia, the tiny hairs that line the inner surfaces of the respiratory system. These particles are then gradually taken away by the body's own mechanisms for removing foreign matter, and they are thereby rendered harmless.

One should note in this discussion of particle sizes that the bioweaponeer must work under certain physical limits. Individual bacteria, such as *Bacillus anthracis,* for example, range in size from roughly one-half micron to 2–3 microns or more in diameter. To fashion bacteria into some sort of weapon, therefore, requires that the pathogens be separated into small enough particles, averaging less than 10 microns in diameter. Processing the biological material to such a fineness while maintaining its viability is technically demanding. Although finding, growing, and preparing bacteria is not technically difficult, producing a complete weapon system to deliver these agents in the desired aerosol parameters is no easy task.

Because BW agents almost exclusively require the utilization of aerosols to cause infection, one form of ready defense is simply filtering the air with a mask or with the filters found in collective shelters. One U.S. Army study showed that doubling over a towel once or twice and holding this over the nose and mouth was sufficient to filter out most particles in the sizes necessary for causing infection through the inhaled route. But though such protective measures are effective in theory, in practice one needs to first know that a biological attack is taking place. Aerosols are silent, invisible, and at present can only be detected in real time with special light-scattering techniques. Thus, it is unlikely that most people under a biological attack would be able to don protective masks in time to be of any use.

BW Agent Types

Bacteria

There are three main categories of BW agents: bacteria, viruses, and toxins. Bacteria are organisms that are more primitive than the cells making up animal tissue and that, with the right nutrients, can live and replicate by division. Bacteria used in yogurt, those that exist normally in the human gut (such as *Escherichia coli*), and anthrax bacteria (*Bacillus anthracis*) are all examples of bacterial organisms. Within the classification of bacteria is a family of rickettsial organisms. These are bacteria that can only survive in host organisms (i.e., living tissue); some rickettsia can cause serious disease in animals and humans, including typhus (*Rickettsia prowazekii*), Q-fever (*Coxiella burnetii*) and Rocky Mountain spotted fever (*Rickettsia rickettsii*). All three of these organisms have the potential to be used in biological weapons. The United States, for example, produced Q-fever as a weapon during the Cold War and researched Rocky Mountain spotted fever in a number of biological tests for weaponization. Typhus bacteria also may have been a part of the early Soviet BW program.

Viruses

Viruses are usually much smaller than bacteria. One of the largest viruses that cause disease in humans, smallpox (*Variola major*) virus, measures about 0.3–0.4 microns in diameter, or roughly one-tenth the size of anthrax bacteria spores. Viruses also differ from bacteria in their structure, and they are dependent upon living cells (prokaryotic, e.g., bacteria and eukaryotic, e.g., animal cells) for replication. In nature, viruses can be spread in ways similar to those of bacterial infections, such as vectors (e.g., mosquitoes) and contact with infectious hosts. But also like some bacterial diseases, many viruses are spread by aerosols and large infectious droplets, particularly through formation of infectious particles generated by coughing or sneezing.

Viruses can be harmless or can cause diseases, some more serious than others. Some viruses can grow quickly and create symptoms of disease within days or weeks, but others may take a much longer time to cause illness. The Human Immunodeficiency Virus (HIV), which causes Acquired Immunodeficiency Syndrome (AIDS), and the rabies virus are examples of infections that are fatal but that take considerable time before infected individuals may become deathly ill. For use as a biological weapon, the pathogen would need to be one that can cause disease quickly and that is likely to infect most humans following exposure. A viral BW agent would also require a formulation that could be disseminated in the form of an aerosol to be most effective in a biological weapon.

Toxins

Unlike CW agents that are synthetically manufactured, BW toxins are molecules produced by living organisms. One toxin, for example, is produced by the bacteria *Clostridium botulinum* and is the cause of some very serious forms of food poisoning (botulism). (*Botulus* is the Latin word for *sausage,* as the disease has long been associated with tainted meat products.) The toxicity of botulinum toxin is variously estimated to be lethal in amounts ranging from about 0.1 micrograms (ingested) to 5 micrograms (inhaled), the latter figure being 200 times smaller than the estimated lethal dose of the most toxic nerve agent, VX. However, the actual delivery of botulinum would present more difficulties than VX. Botulinum toxin is rather fragile, and if its chemical structure and integrity are damaged (denatured), it will cause no harm. Also, whereas VX can act through the skin, botulinum toxin must be delivered in the form of an aerosol or introduced into the body through wounds, injection, or ingestion. One biological toxin that is unusual in this respect is T-2, a compound derived from some species of *Fusarium* mold. This compound is especially toxic to skin upon contact. It is not clear, however, if T-2 was ever produced or used in any form as a means of warfare, although it and other trichothecene mycotoxins are suspected as being the active ingredient in yellow rain.

Using Biological Weapons

One major difference between CW and BW is that biological weapons, all other things being equal, have much more delayed effects (measured in days to weeks), whereas CW agents cause injury and death much more quickly (measured in minutes to hours). One can think of BW as the use of infectious disease against an enemy. There is usually a certain latent or incubation period between exposure to microbes and the appearance of actual disease symptoms. Like CW agents, some biological toxins may have faster action than others, perhaps only hours to a day or so before the effects become known. Staphylococcal enterotoxin B (SEB), for example, has a relatively short latent period. In cases of SEB ingestion or inhalation, symptoms may appear in a matter of a few hours (or less). Botulinum toxin, on the other hand, requires 12 to 24 hours or more before it takes effect.

Theoretically, any disease or disease-causing toxin could be fashioned into some sort of weapon. (See the sidebar for a list of potential BW agents.) However, only a small percentage of disease-causing agents are practical for large-scale biological attacks on humans. Bioterrorism could also involve a number of disease-causing microbes (pathogens) or toxins, although attacks using these would probably be on a smaller scale.

Because BW is essentially warfare by means of infectious disease—public health in reverse—it is important in studying BW to understand how microorganisms or their toxins cause injury or death. Anthrax is often cited as a typical BW agent, and it has been used in acts of terrorism both in Japan and, with more success, in the United States. Again, the importance of the aerosolized dissemination route of exposure cannot be understated. Using *Bacillus anthracis,* the bacteria that causes anthrax, involves the production of anthrax bacterial spores. As opposed to the growing and dividing phase of the bacterial life cycle, spores are very similar in concept to seeds of a plant. Although not part of a reproductive cycle, the bacterial endospore (or spore) is a means by which a bacterium can ensure its own survival. When faced with a lack of food or when under other physical stress, spore-forming bacteria like *Bacillus anthracis* and *Coxiella burnetii* can convert from their growth phase into a smaller, more spherical shape that includes a very thick, protective outer wall. This spore can remain in a stage of hibernation until it finds another environment with nutrients, water, and more favorable conditions. For use in a weapon, these spores are produced in such a way that they can be easily disseminated in an aerosol.

When the victim breathes in anthrax spores, tens to hundreds to thousands of spores (data are incomplete with regard to infectivity in humans) are necessary to cause disease, depending upon the individual. (In the case of Q-fever, it may require fewer than ten spores in order to cause infection. The resulting disease, however, is much less serious than inhalation anthrax.) If they are of the right particle size, they can reach the alveoli in the lungs. Here, they may sit for a while and do nothing until picked up by special cells that pick up foreign matter. These macrophages will surround the anthrax spore and carry it to the nearby lymph. (The lymphatic system is a special draining system that the body uses to rid itself of foreign bodies and

SELECTED PATHOGENS WITH POTENTIAL FOR USE IN BIOLOGICAL WARFARE

HUMAN/ZOONOTIC PATHOGENS
Viral Pathogens
Arenaviridae (Old World)
Lassa fever
Mopeia (Mozambique, Zimbabwe)

Arenaviridae (New World)
Flexal hemorrhagic fever (Brazil)
Guanarito hemorrhagic fever (Venezuela)
Junin hemorrhagic fever (Argentine)
Lymphocytic choriomeningitis
Machupo hemorrhagic fever (Bolivia)
Sabia hemorrhagic fever (Brazil)

Bunyaviridae
Akabane (hantavirus)
Belgrade (Dobrava)
Bhanja (nairovirus)
Crimean-Congo hemorrhagic fever (CCHF) (nairovirus)
Germiston
Hantaan (hemorrhagic fever with renal syndrome) (hantavirus)
Oropouche
Rift Valley fever
Seoul (hantavirus)
Sin Nombre (formerly Muerto Canyon)

Caliciviridae
Hepatitis E

Filoviridae
Ebola
Marburg

Flaviviridae
Absettarov (tick-borne group)
Dengue
Hanzalova (tick-borne group)
Hepatitis C
Hepatitis G
Hypr (tick-borne group)
Israel turkey meningitis
Japanese encephalitis
Kumlinge (tick-borne group)
Kyasanur Forest (tick-borne group)
Louping-Ill (tick-borne group)
Murray Valley encephalitis
Negishi (tick-borne group)
Omsk hemorrhagic fever (tick-borne group)
Powassan (tick-borne group)
Rocio
Russian spring-summer encephalitis (tick-borne group)
St. Louis encephalitis
Sal Vieja
San Perlita
Spondweni
Tick-borne encephalitis
Wesselsbron
West Nile fever
Yellow fever

Hepadnaviridae
Hepatitis B
Hepatitis D (delta)

Orthomyxoviridae
Influenza (Ad Hoc Group, BWC)

Paramyxoviridae
Hendra Complex viruses (equine morbillivirus)
Menangle
Nipah

Poxviridae
Alastrim (*Variola minor*)
Monkey pox
Smallpox (*Variola major*)

Rhabdoviridae
Piry
Rabies

Retroviridae
Human immunodeficiency viruses (HIV)
Human T-cell lymphotropic viruses (HTLV) types 1 and 2
Simian immunodeficiency virus

Togaviridae
Chikungunya
Eastern equine encephalitis
Everglades
Getah
Middleburg
Mucambo
Ndumu

(continues)

SELECTED PATHOGENS *(continued)*

Sagiyama
Tonate
Venezuelan equine encephalitis (VEE)
Western equine encephalitis (WEE)

Unclassified Viruses
Borna disease
Hepatitis viruses not yet identified
Transfusion-transmitted viruses

Transmissible Spongiform Encephalopathies (TSEs)
Bovine spongiform encephalopathy (BSE, or mad cow disease) and other related TSEs
Creutzfeldt-Jakob disease and variants
Fatal familial insomnia
Gerstmann-Sträussler-Scheinker syndrome
Kuru

Bacteria
Bacillus anthracis (anthrax)
Bartonella quintana (formerly *Rochalimea quintana*), trench fever
Brucella abortus (brucellosis)
Brucella canis
Brucella melitensis (brucellosis)
Brucella ovis (not known to be a human pathogen; Ad Hoc Group, BWC)
Brucella suis (brucellosis)
Burkholderia mallei (glanders)
Burkholderia pseudomallei (melioidosis)
Chlamydophila psittaci (formerly *Chlamydia psittaci*)
Closteridium tetani (tetanus)
Clostridium botulinum ("Botulinum neurotoxin-producing strains of Clostridium," according to CDC [Centers for Disease Control])
Clostridium perfringens (gas gangrene)
Corynebacterium diphtheriae (diptheria) Ad Hoc Group, BWC
Escherichia coli (enterohaemorrhagic, e.g., O157H7)
Francisella tularensis (tularemia) (UKNCC list notes Type A only [class 3 pathogen])
Legionella pneumophila (legionnaires' disease)
Mycobacterium africanum
Mycobacterium avium/intracullulare
Mycobacterium bovis
Mycobacterium kansasii
Mycobacterium leprae
Mycobacterium malmoense
Mycobacterium microti
Mycobacterium scrofulaceum
Mycobacterium simae
Mycobacterium szulgai
Mycobacterium tuberculosis
Mycobacterium ulcerans
Mycobacterium xenopi
Salmonella paratyphi A, B, C (paratyphoid)
Salmonella typhi (typhoid)
Shigella dysenteriae (dysentery)
Vibrio cholerae (cholera)
Yersinia pestis (plague)
Yersinia pseudotuberculosis

Rickettsiae
Coxiella burnetii (Q-fever)
Ehrlichia spp. (e.g., *Ehrlichia sennetsu,* formerly known as *Rickettsia sennetsu*)
Rickettsia akari
Rickettsia Canada
Rickettsia conorii
Rickettsia Montana
Rickettsia prowazekii (epidemic typhus)
Rickettsia rickettsii (Rocky Mountain spotted fever)
Rickettsia tsutsugamushi
Rickettsia typhi (*Rickettsia mooseri*)
Rochalimaea spp.

Fungi
Blastomyces dermitidis (*Ajellomyces dermatitidis*) (blastomycosis)
Cladophialophora bantiana (formerly known as *Xylohypha bantiana, Cladosporium bantianum*)
Coccidioides immitis
Coccidioides posadasii
Histoplasma capsulatum (incl. var. *duboisii*)
Histoplasma capsulatum var. *farcinimosum*
Histoplasma capsulatum var. *capsulatum* (*Ajellomyces capsulatus*)
Paracoccidioides brasiliensis
Penicillium marneffei

Parasites
Echinococcus granulosus
Echinococcus multilocularis
Echinococcus vogeli
Leishmania brasiliensis
Leishmania donovani
Naegleria fowleri (naegleriasis, amoebic meningoencephalitis)
Plasmodium falciparum (malaria)
Taenia solium (pork tapeworm, cysticercosis)
Trypanosoma brucei rhodesiense
Trypanosoma cruzi

Toxins
Abrin
Aflatoxins
Botulinum (botulinum neurotoxins, according to CDC)
Cholera
Closteridium perfringens (APHIS: epsilon toxin)
Cobra venom
Conotoxin
Corynebacterium diphtheriae toxin
Diacetoxyscirpenol (DAS)
HT-2
Microcystin (cyanginosin)
Modeccin
Ricin
Saxitoxin
Shiga (includes shiga-like toxins, according to CDC)
Staphylococcus aureus toxins (enterotoxins)
T-2 (trichothecene mycotoxin)
Tetanus
Tetrodotoxin
Verotoxin
Verrucologen (*Myrothecium verrucaria*)
Viscum album lectin 1 (viscumin)
Volkensin

ANIMAL PATHOGENS
Animal Viruses
African horse sickness
African swine fever
Aujeszky's disease (porcine herpes)
(Highly pathogenic) avian influenza
Bluetongue
Camel pox
Classical swine fever (hog cholera)
Foot-and-mouth disease
Goat pox
Horse pox
Lumpy skin disease
Lyssa
Malignant catarrhal fever
Newcastle disease
Peste des petits ruminants
Porcine enterovirus type 9, also known as swine vesicular disease (SVD)
Rabies
Rinderpest
Sheep pox
Simian herpes B
Teschen disease
Vesicular stomatitis
Whitepox (poxviridae; African monkeys and rodents)

Animal Bacteria
Mycoplasma mycoides var. *capri* (goats, i.e., contagious caprine pleuropneumonia)
Mycoplasma mycoides var. *mycoides* (small colony: contagious bovine pleuropneumonia)

Animal Rickettsia
Cowdria ruminantium (heartwater)

PLANT PATHOGENS
Plant Viruses
Banana bunchy top
Plum pox potyvirus
Sugar cane Fiji disease (Ad Hoc Group, BWC)

Plant Bacteria
Citrus greening disease (*Candidatus*)
Erwinia amylovora, fire blight of apple (Ad Hoc Group, BWC)
Erwinia carotovora (Ad Hoc Group, BWC)
Liberobacter africanus and *Liberobacter asiaticus* (huanglongbing, yellow dragon disease)
Ralstonia solanacearum (*Pseudomonas solanacearum*), tomatoes (Ad Hoc Group, BWC)
Xanthomonas albilineans (leaf scald)
Xanthomonas campestris pv. *Aurantifolia* (Ad Hoc Group, BWC)
Xanthomonas campestris pv. *Citri*
Xanthomonas campestris pv. *oryzae* (leaf blight, bacterial leaf blight)
Xanthomonas citri
Xanthomonas oryzae pv. *oryzae*
Xylella fastidiosa

Plant Fungi
Bipolaris oryzae (*Helminthosporium oryzae, Cochliobolus miyaeanus*), brown spot of rice
Colletotrichum coffeanum var. *virulans* (*Colletrichum kahawae*)
Deuterophoma tracheiphila (*Phoma tracheiphila*), mal secco disease
Dothistroma pini (*Scirrhia pini*) needle blight on/of pine (Ad Hoc Group, BWC)
Microcyclus ulei (*Dothidella ulei*), South American leaf blight
Moniliophthora rorei (*Monilia rorei*), cocoa moniliasis
Peronosclerospora philippinensis (Philippine downy mildew)
Phakopsora pachyrhizi
Phytophthora infestans, late blight of potato (Ad Hoc Group, BWC)

(continues)

SELECTED PATHOGENS *(continued)*

Puccinia erianthi (also known as *Puccinia melanocephala*), orange rust of sugar cane (Ad Hoc Group, BWC)
Puccinia graminis f. sp. tritici (rust fungus)
Puccinia striiformis (wheat yellow rust) (Puccinia glumarum)
Pyricularia grisea (formerly known as *Pyricularia oryzae,* also *Magnaporthe grisea*), rice blast fungus
Sclerophthora rayssiae var. *zeae* (brown stripe downy mildew)
Sclerotinia sclerotiorum, sclerotinia rot (Ad Hoc Group, BWC)
Soybean rust
Synchytrium endobioticum (potato wart)
Tilletia spp. (wheat cover smut) (Ad Hoc Group, BWC)
Ustilago maydis, corn smut

Destructive Plant/Fruit Insects
Ceratitis capitata (Wiedemann; Ad Hoc Group, BWC)
Mediterranean fruit fly (medfly)
Thrips palmi Karny (Ad Hoc Group, BWC)
Western flower thrips *Frankliniella occidentalis* (Pergande; Ad Hoc Group, BWC)

pathogens.) In some instances, however, when the *Bacillus anthracis* spores infiltrate the lung, instead of being dissolved and drained from the body, the pathogenic bacteria begin to grow and multiply. These bacteria would ordinarily be captured and killed by the body's immune system. Disease-causing forms of anthrax, however, produce a protective covering (capsule) that prevents the body from effectively finding, fixing, and destroying them. Anthrax bacteria then excrete a toxin complex: one component, called protective antigen (PA), is connected to another part called the lethal factor (LF) component. PA binds with cell receptors in the body, allowing the LF toxin to gain entry into the host's cells. Cell damage and death due to the LF toxin causes the body to make a frantic effort to fight off the disease, bringing about severe inflammation and producing fever, nausea, vomiting, and swelling of tissues. Unless treated aggressively with antibiotics, inhalation anthrax usually causes death in humans if not caught in the early stages of disease.

Other bacteria, such as plague and tularemia, also cause disease by toxic elements built within their cellular structures. Plague, unless treated with antibiotics, is likely to be quite deadly, especially if inhaled as an aerosol. Tularemia also can be deadly, but with treatment most victims will survive this disease.

Also best delivered in aerosol form, viral BW agents cause disease as they take over the cellular machinery in the body and use these to replicate themselves. The viruses can continue to infect more and more cells, killing them as they go in some cases, causing various disease symptoms such as headache, fever, chills, and nausea. Viral BW agents include smallpox, viruses that cause severe bleeding in tissues (hemorrhagic fevers), and viruses that cause severe disease in horses (such as Venezuelan Equine Encephalitis) but also produce illness in humans. VEE virus, grown in fertilized chicken eggs during the Cold War, was an important BW agent in both the U.S. and Soviet biological weapons arsenals. This virus can also be grown in other types of tissue culture and can be prepared in dry powder form for wide dissemination as an aerosol. Although most individuals exposed to this virus will contract the disease, and the symptoms (flulike and worse) are severe, few will die from VEE infection. For use by militaries against large, well-populated targets, VEE virus can cause widespread incapacitation of the enemy forces and their civilian populations.

BW Defense

The first line of defense against BW is early detection of the toxin or pathogen. This is most likely to be accomplished by health care professionals and by laboratories designed to identify microbial diseases and related toxins. (In 2004, work was underway to detect aerosols at a distance and to define those that constitute a biological threat; however, these devices are still in the early stages of technical reliability.) Probably, the first sign of a BW attack would be actual cases of disease that are diagnosed by physicians in a hospital, clinical laboratory, or medical office.

Once the BW agent has been identified, the next course of action would include treating the individual patient but also starting an aggressive public health action plan to treat other possible exposures.

Some BW agents can be treated with vaccines if the exposure to the agent is detected early. Smallpox is a good example. Being a disease that is easily transmitted from one person to another, it would be critical to vaccinate anyone near or in contact with the victim. This can both protect those exposed individuals from smallpox infection and slow or stop the spread of smallpox in the community. Without adequate vaccination, smallpox could spread like wildfire and could rage out of control even with strict measures to keep people from traveling or interacting outside their homes and neighborhoods.

Vaccines can be used against anthrax and plague, although at present it is not certain how effective these would be against inhalation forms of either disease. Vaccinations also would have to be done well ahead of time, days or preferably weeks before the actual BW attack. Some toxins also have vaccines (toxoids) for protection against exposure, such as that used for botulinum. Again, communities need to have an accurate threat picture and adequate time before the actual attack for these to be successful.

In most cases, vaccines would be most critical for contagious BW diseases like smallpox, and to a certain extent plague (in its pneumonic form). Other BW agents, however, are not known to be contagious. Bacterial and rickettsial diseases are treatable with antibiotics. Viral diseases are for the most part not successfully treatable with chemotherapy, although some antiviral medications have been shown to be efficacious in some instances. But for most viral infections, all that can be done is to provide supportive care to the victim—fluid replacement, breathing assistance, and pain regulation. These can be quite effective in reducing overall mortality.

—Eric A. Croddy

See also: Chemical and Biological Munitions and Military Operations; Kaffa, Siege of; Protective Measures: Biological Weapons; Vaccines

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BIOLOGICAL WARFARE PROTECTIVE MEASURES

See Protective Measures: Biological Weapons

BIOLOGICAL WEAPONS CONVENTION (BWC)

See Biological and Toxin Weapons Convention

BIOPREPARAT

During the latter half of the twentieth century, the Soviet Union (and later, to a much more limited degree, Russia) possessed the largest and most advanced biological weapons technology and production infrastructure ever known. The Soviet organization known as Biopreparat was ostensibly devoted to civilian biotechnology. It was, in fact, the research and development arm for the Soviet military to produce biological warfare agents and munitions. Some open source documents provide glimpses into past Soviet activities in offensive biological warfare. Much of what is known from the open literature about the former Soviet BW program, however, is based upon the testimony of Soviet defectors, including Vladimir Pasechnik, Ken Alibek, and other participants in the Biopreparat program.

Biopreparat—a parallel entity to the Soviet Ministry of Defense (MOD), from which it obtained financing—was officially subordinate to the civilian Main Administration of the Microbiological Industry

(Glavmikrobioprom). Referred to as the Concern, Biopreparat during its 20 years of activity (from 1972 until about 1992) served as the main technology and manufacturing base for the antihuman biological warfare (BW) agents in the former Soviet Union. Although its charge was to conduct offensive BW research and development, Biopreparat also produced civilian pharmaceuticals and was the second largest manufacturer of antibiotics in the world.

The civilian nature of Biopreparat and its connection with military biology is not surprising. The creation of a civilian-styled organization for developing biological weapons followed a Soviet pattern established decades before Biopreparat was formed. For example, because of the endemic nature of plague (sometimes called Black Death) throughout the Eurasian continent, it was logical that Soviet scientists had developed an extensive antiplague system for disease monitoring and surveillance. Such a civilian-oriented system would actually have dual roles: public-health-related research into infectious diseases, and militarily useful work in developing biological warfare (BW) agents. By the 1950s, the semblance of an infrastructure—again, civilian, at least in outward appearance—for biological weapons development had already been established in the Soviet Union. Referred to in official-speak as Problem No. 5, offensive biological weapons research and development was carried out by these antiplague and related organizations.

By the end of its biological weapons program (1992), the Soviet military had weaponized several viruses: smallpox, Venezuelan equine encephalitis (VEE), and Marburg. In the development stage were other hemorrhagic fevers, including Ebola, Lassa, Russian spring-summer encephalitis, Argentine and Bolivian hemorrhagic fevers, and possibly others. Lethal bacteria in the Soviet biological weapons arsenal included an especially potent form of anthrax (*Bacillus anthracis*), with less deadly but still virulent tularemia (*Francisella tularensis*) and *Brucella spp.* bacteria. (The latter BW agent was later replaced by the incapacitating biological agent glanders, or *Burkholderia mallei.*) Another incapacitating agent, Q-fever (*Coxiella burnetti*), was also produced in the Soviet Union, but like *Brucella,* it, too, eventually fell out of favor as a weapon. According to Ken Alibek, work with botulinum toxin was conducted in the mid-1970s. But aside from their roles as assassination weapons (such as those developed by Soviet KGB scientists), little is known about the role of this toxin and others in the Soviet BW program.

Brief History of Soviet Biological Weapons

Following the establishment of the Bolshevik regime in 1917, the Soviet biological weapons program grew in fits and starts. Begun largely because of the great losses Russia suffered in World War I, especially from chemical warfare, it is likely that past experience with diseases (e.g., typhus) were was a deciding factor in the Soviet Union's starting the program. The Soviet BW program would be interrupted by Stalin's purges and by the rise of Lysenkoism (see below), and then it would be reborn with the dawn of new discoveries in genetics.

The Soviet biological weapons program can be roughly divided into two phases: 1) the initiation of a full-fledged biological warfare program in 1928, and 2) the resurgence in the pursuit of military biotechnology following Lysenkoism in the early 1970s. Serious efforts on the part of the Soviet Union to develop biological weaponry took place just after signing arms control agreements meant to stem such activity.

In 1928, Yakob Moiseevich Fishman recommended to Red Army Commissar Kliment Voroshilov that the Soviet Union initiate biological weapons development. That same year, the Soviet Union acceded to the Geneva Protocol of 1925, forbidding the use (albeit with many loopholes and exceptions) of chemical and "bacteriological" warfare. Similarly, in 1975, when the Soviet government officially ratified the 1972 Biological Toxin and Weapons Convention (BTWC), it had already begun a massive project for military biological research and weapons production. A year after signing the BTWC, an organization was formed by the Soviet government that would be tasked with biological weapons research, development, and manufacture: the All-Union Science-Production Association, or Biopreparat (Order No. 131, April 1974).

Prelude to Biopreparat: Lysenko

The Soviet Union's decision to reinvigorate its offensive BW efforts followed a period termed Lysenkoism—or the Russian pejorative *Lysenkovshchina.* Until the 1970s, Soviet scientists had to their credit many advances in applied and basic research. But in the field of biology, the Soviet Union had in many areas fallen far behind the West. This state of affairs could largely be blamed on one person, the Ukrainian-born agronomist Trofim D. Lysenko (1898–1976). Lysenko relied on extensive self-promotion to make up for a lack of knowledge in the scientific field in which he eventually chose to work.

After receiving a certificate in agronomy in 1925, Lysenko started his professional career as an agricultural technician in Azerbaijan. While Lysenko was growing a batch of peas, a *Pravda* (a Russian newspaper) correspondent took special note of the young scientist, impressed most of all by Lysenko's proletarian origins. Through means of journalistic hyperbole, Lysenko was suddenly credited with making a qualitative leap in agricultural technique: the ability to grow abundant yields of crops in the winter soil. Emboldened by this publicity, Lysenko went on to claim that winter wheat could be grown to fantastic yields if the seeds were exposed to cold temperatures and were planted in spring instead of autumn. He was made responsible for directing the planting of wheat in the collective farms, and exaggerated claims of his yields were widely distributed. But what would turn out to be disastrous methods of Stalinist collectivization would only make Lysenko all the more famous.

Based on his own inchoate understanding of the science and without diligent scruples, Lysenko then turned his sights on genetics. He would later claim that geneticists, and all of those who accepted Mendelian laws, were wreckers, enemies of socialism and therefore enemies of the state. With the unfailing support of Stalin (who had a talent for ruthlessness and who, like Lysenko, came from modest, peasant beginnings), thousands of Russian scientists who did not toe the official line—especially the geneticists among them—were subsequently arrested and sent to the infamous gulags (labor camps). Many more were simply ostracized. In 1953, when Watson and Crick published their groundbreaking research on the DNA double helix, some of this antigenetics campaign was halted. But Lysenko's opinions on biology, particularly his animus against modern genetics, continued to influence the country until at least the mid-1960s, and ultimately, its effects were still felt long after Lysenko's death.

In the early 1970s, the forceful personality of a well-regarded Soviet molecular biologist, academician Yuri Ovchinnikov, entered the battle over the future of genetic research inside the Soviet Union. Unlike Lysenko, who derided scientific knowledge drawn from other countries, Ovchinnikov read the foreign scientific journals and knew of the advances in Western biotechnology. According to Ken Alibek, who was former deputy director of Biopreparat until his defection to the West in 1992, Ovchinnikov "decided to resolve the crisis in Russian biology by appealing to the self-interest of the masters of our [i.e., Soviet] militarized economy. In 1972, he asked the Ministry of Defense to support a genetics program devoted to developing new agents for biological warfare" (Alibek, p. 41). If many top Soviet leaders were unimpressed by Ovchinnikov's proposals, President Leonid Brezhnev was highly receptive. After all, if the Soviet Union were falling behind in scientific technology—no less being surpassed by its nemesis the United States and its NATO allies—this would require decisive action.

That same year (1972), the Soviet Council of Ministers also convened the Interagency Science and Technology Council on Molecular Biology and Genetics (ISTCMBG). This council was comprised of leaders from within the Soviet military, the Academy of Sciences, and the Ministries of Health and Agriculture. Chairing this secret body was Vladimir Zhdanov, an accomplished microbiologist whose specialty was viruses. The post of deputy director was held by Igor Domaradsky. Domaradsky had earlier been the director of antiplague systems during the 1950s, and having expertise with plague (*Yersinia pestis*), he would play a critical role for later research into weaponizing the bacterium. (This was no mean feat. During the 1950s and 1960s, when the United States still possessed an offensive BW program, American scientists tried to devise a plague-based weapon but were unsuccessful.) Along with Biopreparat, these individuals and organizations would play a crucial role in the research and development of biological weapons.

Organizations and Laboratories within Biopreparat

In 1973, Biopreparat had been formally established under the code name *Fermenty* (Enzymes). Requirements for biological weapons research and development were set according to the decisions made by the ISTCMBG. Located in Moscow, Biopreparat was listed simply as Post Office Box A-1063. The first director, a lieutenant general at the time, was Vsevolod Ivanovich Ogarkov. Thus, the military biological activities of Biopreparat were informally known in Russia as "*Sistema Ogarkova,*" or Ogarkov's System. Despite its civilian trappings, Biopreparat's institutes and production facilities were actually run by the fifteenth Directorate of the Soviet Ministry of Defense.

Alibek, who had been the organization's first deputy director from 1988 to 1991, reported that Biopreparat was meant to be the primary production source of biological warfare agents in the event of a war footing or outright hostilities with the West. Thus, in peacetime, Biopreparat was mostly on a "standby footing." "Mobilization" facilities included the Scientific Design Institute and Factory of Biopreparations Complex in Berdsk, Novosibirsk, Siberia; the Scientific Research Institute of Microbiology in Kirov (now Vyatka), 150 miles southwest of Moscow; and the Center for Military-Technical Problems of Anti-Bacteriological Defense in Sverdlovsk (now Yekaterinberg). There were several other important elements of the Biopreparat network. The State Scientific Center of Applied Microbiology was located in Obolensk (about 60 miles south of Moscow). This facility was involved in biological weapons research, including the genetic manipulation of microbial agents and their testing in aerosol chambers. Established in 1974 during the height of the Soviet BW program, the Center had a staff of about 1,500 people, half of whom were research scientists.

The Center of Virology in Zagorsk (now Sergiyev Posad), was located 50 miles northeast of Moscow. According to Alibek, the Center produced smallpox to meet an annual stockpile quota of 20 tons. Based on a highly virulent strain obtained from an Indian smallpox patient in 1967, this weapon had a refrigerated shelf life of six months. In the event of a nuclear exchange with the United States, smallpox virus (and other BW agents) was to be loaded in liquid form in bomblets on the SS-18 intercontinental ballistic missile (ICBM).

The Institute of Immunological Design was located in Lybuchany (outside Moscow) and was under the direction of Vladimir Petrovich Zav'yalov. In the 1980s, this institute was charged with the development of tularemia vaccine and diagnostic testing kits.

The State Scientific Center of Virology and Biotechnology (Vector) was located in Koltsovo (Novosibirsk, Siberia). The Main Administration of the Microbiological Industry (Glavmikrobioprom) established Vector in March 1985. In the early 1990s, Vector had a staff of about 3,000. Vector is one of two official repositories of the smallpox virus, the other being the U.S. Centers for Disease Control and Prevention (CDC), in Atlanta, Georgia.

The State Scientific Institute of Ultrapure Biological Preparations was located in Leningrad (now St. Petersburg). This facility was a crucial link in developing a technological basis for weaponizing BW agents, particularly the creation of very fine aerosols. Under the leadership of Vladimir Pasechnik—who in 1989 would defect and reveal to the West many secrets of the Soviet biological weapons program—the Institute was involved in the manufacture of cruise missiles capable of delivering infectious aerosols.

The Scientific Experimental and Production Base was located in Stepnogorsk, Kazakhstan. Stepnogorsk is a Stalinesque town built largely for uranium mining, located in the otherwise desolate steppes of northern Kazakhstan. It also held the largest biological weapons facility in the world. Due to an accident caused by a release of anthrax spores at Sverdlovsk (now Yekaterinberg) in 1979, production of anthrax was moved to Stepnogorsk because the Scientific Experimental and Production Base possessed superior air handling capabilities and was in a remote location. During a time of conflict, tons of anthrax could have been produced there within two weeks. Built at an estimated cost of 1 billion rubles (approximately U.S. $1 billion), the massive complex of buildings, tunnels, bunkers, and 20,000-liter fermenters at Stepnogorsk has since the end of the Cold War been gutted and almost completely destroyed. What remained of the equipment and staffing was converted to a commercial enterprise to produce commercial products ("joint-stock company") in 1993.

In addition to the testing of a variety of other BW agents, including Marburg virus, the Stepnogorsk facility was charged with the manufacture of weapons-grade anthrax and plague. With advances made in the 1980s in producing virulent strains of bacteria, it was here that Alibek managed the development of the 836 strain of weaponized anthrax, probably the most lethal ever produced.

Also located in Kazakhstan near the Uzbekistan border was Vozrozhdeniye (Rebirth) Island. After 1952, this was the Aral test facility, Aralsk-7, a biological weapons proving ground for the Soviet military. Biological weapons testing at this installation was likely the cause of a smallpox outbreak in 1971 near Rebirth Island.

At its peak, Biopreparat had an estimated 40,000–60,000 personnel, with about 40 laboratories and production facilities spread across much of the former Soviet territory. Even during the Gorbachev years (1986–1990) of Perestroika, a five-year plan continued to weaponize the Ebola, Marburg, and smallpox viruses. As far as it is known, however, the biological-weapons-related activity and associated elements of Biopreparat have largely been disbanded.

—Eric A. Croddy

See also: Aralsk Smallpox Outbreak; Russia: Chemical and Biological Weapons Programs; Stepnogorsk; Sverdlovsk Anthrax Accident

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BIOREGULATORS

Bioregulators, or bioregulatory peptides, are genetically coded chains of amino acids that are produced naturally in the human body and are essential for normal physiological functioning. These substances resemble toxins in their nature and action, and in technical terms can in fact be defined as toxins, in that they are "chemicals of biological origin." Though the role of bioregulators in controlling biological processes has only begun to be understood, their effects are known to range from the mediation of sensations such as fear and pain to the regulation of the body's vital signs, namely blood pressure, heart rate, and respiration. When present at inappropriately elevated levels (e.g., as a result of intentional introduction into the body), a bioregulator can overwhelm the body's compensatory mechanisms, and its actions can go unchecked. Potential consequences include the sensation of pain, loss of consciousness, altered blood pressure, and altered psyche. These consequences, although profoundly incapacitating, are generally not lethal, although death is possible under certain circumstances.

In theory, a bioregulator can be introduced into the body in one of two ways. First, it can be introduced by using well-established genetic engineering techniques; the gene that codes for the bioregulator can be inserted into a microorganism, which is then delivered into the body via injection, ingestion, or inhalation. Upon gaining entry into the body, the microorganism produces the bioregulator, and its effects are felt. Second, the bioregulator itself can be chemically or enzymatically synthesized in a laboratory. Once a quantity of the bioregulator has been produced, it can be delivered on its own, again via injection, ingestion, or inhalation, in the same manner that any other biological weapon (or pharmaceutical agent, for that matter) would be delivered.

Bioregulators lend themselves to rapid synthesis due to the abbreviated nature of their constituent amino acid chains, and commercial and scientific developments have made the production of various peptides possible on a large scale. For example, 4 million kilograms of NutraSweet—a simple peptide consisting of two amino acids, aspartic acid and phenylalanine—were manufactured per year in the late 1980s. Such production has become increasingly affordable, and the synthetic techniques employed further allow for the enhancement not only of a bioregulator's potency, but also of properties such as its activity and selectivity, all of which helps to create a powerful, highly specific, and potentially very dangerous analogue. Given both the production and manipulation potential of bioregulators, the future illicit development—and subsequent use—of these substances cannot be ruled out.

Research in the Soviet Union

Soviet bioweaponeers engaged in extensive research on bioregulators throughout the 1980s under the code name Project Bonfire. As reported during a conference of Soviet scientists in 1989, the project had been a success: the gene coding for the bioregulator myelin toxin, named as such by the Soviets for its ability to damage the myelin sheaths of neurons and thus disrupt nerve transmission throughout the body, had been identified and—through the application of advanced recombinant DNA techniques—inserted into the bacterium *Yersinia pseudotuberculosis.* In laboratory tests, this single agent caused both the symptoms of the pathogen and the paralytic effects of myelin toxin. Notably, *Yersinia pestis,* the causative agent of plague, is closely related to *Y. pseudotuberculosis,* suggesting the possibility of transfer of similar genetic material into this potentially contagious, lethal pathogen to create an enhanced and truly formidable biological weapon. It has been reported that Soviet scientists did in fact successfully perform such a transfer before the collapse of the Soviet Union, but that the agent was not developed any further. It is not known whether other bioregulators were researched within the former biological weapons program. It is known, however, that a number of other bioregulators were studied, ostensibly for peaceful purposes, in the Soviet Union throughout the later years of the Cold War and in Russia today.

Research in South Africa

South Africa's apartheid-era chemical and biological weapons program, Project Coast, may have investigated bioregulators. Although the claims are largely unverified and may, in fact, have been criminally motivated, it has been suggested by scientists within the program (and in particular by program leader Wouter Basson himself) that such research was performed at two separate locations: the large-scale chemical weapons research and development facility Delta G Scientific, and the clandestine laboratories of Special Forces headquarters. According to Basson, efforts at the Special Forces laboratory led to the successful production of a peptide derived from the human thymus gland (different thymic peptides exist, each with various actions: alpha-thymosin, for example, is active in the development of a beneficial immune response, and different types of beta-thymosin have been linked to cancer), as well as growth hormone and other unspecified peptides produced by the pituitary gland in the brain.

It is theorized that Basson may have provided this information to substantiate his own claim that he had spent a large amount of government money on a peptide synthesizer. This peptide synthesizer later could not be accounted for, leaving open the possibility that Basson embezzled the funds and that these peptides were never produced by the scientists of Project Coast.

Bioregulators of Importance

Though in fact comprising a very broad category of chemicals, for practical purposes bioregulators can be narrowed in spectrum, based largely on their action and amenability to synthesis, to those with biological warfare (BW) implications. A selection of bioregulators often referred to in a BW context is represented in Table B-1.

Table B-1: Select Bioregulators and Some of Their Effects

Type	*Prototype Bioregulator(s)*	*Primary Effect(s)*
Algogen	Substance P	Sensory transmission of pain
Endogenous opioid	Endorphins, enkephalins	Analgesia similar to morphine
Hormone	Vasopressin	Water retention, vasoconstriction
Endothelium-derived factor	Endothelin	Vasoconstriction

—Rich Pilch

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BIOTERRORISM

Generally speaking, bioterrorism refers to the use of biological agents—microbial pathogens or toxins derived from living organisms—as a means of perpetrating some terrorist attack. This seems simple enough, although arriving at a noncontroversial meaning of the very word *terrorism* can be fraught with difficulty. The U.S. Federal Bureau of Investigation (FBI) defines terrorism as "the unlawful use of force against persons or property to intimidate or coerce a government, the civilian population or any segment thereof, in the furtherance of political or social objectives" (U.S. Code of Federal Regulations, 28 Section 0.85). Forming a textbook definition of bioterrorism is difficult. In discussing bioterrorism, though, it may be much less important what one thinks it is and more important to consider the political, psychological, and emotional impact that might be created by the use of the term to describe some disease outbreak.

The concept of bioterrorism might be seen as different from simple criminality involving pathogens or toxins; one might call these types of events biocriminality or malicious mischief. Unless there is some clear motive that speaks to a wider political or social statement, the simple act of murdering someone by using a biological agent is still technically a homicide.

Often mentioned in the context of bioterrorism is the assassination of the Bulgarian dissident Georgy Markov with ricin toxin. In 1978, the Bulgarian secret service (with technical assistance from the Soviet KGB) assassinated Markov while he was working in London. The motive: Markov had criticized the tyranny of the Bulgarian authorities on Western radio. In a more legalistic view, this state-sponsored assassination of a governmental critic does not fit the typical definition of terrorism. The salient aspect of this case, however, is the fact that a biological toxin—ricin—was used as the weapon. Thus, bioterrorism is often ascribed to many deliberate acts using biological agents, even if the actual purpose does not exactly fit the terrorist model.

Since the Markov case, there have been many other instances of ricin being involved with terrorist activity. Most notably, the Islamist terrorist organization al-Qaeda has instructed its adherents on how to produce ricin from the castor bean plant. In 2003, several terrorists linked with al-Qaeda were discovered in Europe with homemade ricin toxin. These individuals may have been planning attacks on civilians or soldiers by poisoning their food. They were probably interested in ricin because it is relatively easy to acquire, not because it has a great utility as a weapon of mass destruction. Aside from some instances when food or beverages could be contaminated and distributed to many people, ricin appears to be a weapon of choice for assassinating individuals.

A 1984 *Salmonella* bacteria attack in Oregon, and the attempts by the Japanese cult Aum Shinrikyo to use botulinum toxin and anthrax bacteria in the early 1990s (*see* Aum Shinrikyo), have been the most concerted efforts made by nonstate actors to use biological agents in the pursuit of some political agenda—that is, bioterrorism. No one died as a direct result of these biological attacks, although the Rajneeshee cult in Oregon was more successful in terms of actually carrying out a biological attack than Aum Shinrikyo.

The Rajneeshee, a religious organization that established itself in Wasco County, Oregon, made extraordinary efforts to create its own society. Led by an Indian national named the Bhagwan (Hindi for "God") Shree Rajneesh, in 1984 the cult sought to control the Wasco County political establishment by swaying upcoming local elections in its favor. The attack that followed in September 1984 was part of a plan to make as many as possible of the noncult population stay away from the polls, chiefly by means of giving them diarrhea. Cult scientists considered a number of different pathogens that cause diarrhea, including *Giardia lamblia,* a parasite that causes giardiasis, and *Shigella dysenteriae* (bacteria that cause dysentery). Both diseases can be serious, but with modern health care they are usually self-limiting. In the end, the cult's technical advisor in the use of such pathogens, Diane Ivonne Onang (renamed Ma Anand Puja) decided to use *Salmonella typhimurium,* a common cause of food poisoning. In November 1984, cult operatives took vials of *Salmonella* bacteria and contaminated food at supermarkets and restaurants. They especially singled out salad bars at local restaurants for adulteration. As a result of this attack, 751 people became ill with salmonellosis.

An especially disturbing aspect of this case was that this deliberate act of food poisoning was not discovered until at least a year later. Eventually, Oregon prosecutors were able to arrest most of the key operatives involved in the biological attack. But long before the criminal proceedings were to begin, the cult's political aspirations were ultimately defeated by more prosaic circumstances.

Some commentators in 2001 referred to the Oregon case as a terrifying incident (Miller, Engleberg and Broad, 2001, p. 14). However, although there were a large number of casualties, none died as a direct result of the attack. Perhaps the important lesson from the Rajneeshee case is that, instead of disseminating microbes that cause gastrointestinal upset, even more virulent or lethal toxins could have been used.

In Japan, another idiosyncratic religious organization called Aum Shinrikyo—led by a self-styled guru named Shoko Asahara (real name: Chizuo Matsumoto)—looked to biological weapons as part of its agenda for seeking power. Fascinated with technology that included weapons of mass destruction, Aum Shinrikyo cult members lashed out at their enemies, including the government of Japan. After failed attempts to win parliamentary seats as a political party in the early 1990s, Shoko Asahara and his henchmen looked to the apocalypse concept. Their outlook now became more of an Eastern version of that of the Charles Manson family, but with much greater resources at their disposal. From approximately 1990 until 1995, Aum Shinrikyo cult scientists attempted to isolate and culture a number of biological agents, with most of their efforts focused on botulinum toxin and anthrax bacteria (*Bacillus anthracis*). In at least 10 instances during those 5 years, Aum Shinrikyo attempted to disseminate botulinum toxin as an aerosol, and they sprayed bacterial spores of an innocuous strain of anthrax bacteria (sterne) in Kameido ward, Tokyo.

The reasons for Aum Shinrikyo's ultimate failure to cause any harm through their efforts at biological warfare (although they were successful in using sarin, a chemical weapon) are still debated, but several problems encountered by the cult have been identified. Aum Shinrikyo's forays into manufacturing botulinum toxin were doomed from the start because the cult isolated a species of *Clostridium botulinum* bacteria that was not specific for toxicity in humans. An assessment of the cult's attempt to disperse anthrax spores is more complicated. The cult has since admitted (on their revised Internet website) that it did deliberately attempt to spray aerosols containing anthrax spores in 1993, but it claims that it knew the type of bacteria being used was basically harmless. Perhaps the more important aspect of Aum Shinrikyo's biological experiment with anthrax is that it used a potentially devastating, albeit crude, delivery method for anthrax spores.

The events of 2001 involving anthrax bacteria being mailed in contaminated envelopes brought home to the United States the disturbing reality of the bioterrorist threat. It was possible to describe this as a bioterrorist act even before there was a clear understanding of who or what was behind it. In early October 2001, less than a month following the al-Qaeda terrorist attacks on the World Trade Center and the Pentagon, the U.S. Centers for Disease Control and Prevention (CDC) identified a case of inhalation anthrax in Palm Beach, Florida. Two days later, federal and local authorities determined that this unusual case of anthrax infection was the result of a deliberate act. At this point, little more information was available, but it has been labeled a bioterrorist event. This first victim of the anthrax letter attacks died soon after the diagnosis. Later, more victims of anthrax infection were identified, and their exposure to anthrax spores was also associated with contaminated envelopes.

Letters were included in the contaminated envelopes, implying that Islamist terrorists or those with sympathies to them were responsible for mailing the anthrax. But as of 2004, the investigation is still ongoing as to the perpetrators of these attacks. Because at least some of the anthrax spores were delivered in very fine particles, it was belatedly recognized that there were potentially lethal levels of contamination in U.S. Post Office buildings and the Hart Senate building in Washington, D.C. Eventually, twenty-two cases of anthrax were determined to have resulted from direct or indirect exposure to these mailed anthrax spores. Half of these cases took the form of inhalation anthrax; the other eleven victims developed the cutaneous form of anthrax infection. Five died from inhalation anthrax. The costs associated with sampling suspect letters, decontaminating buildings, and using X-ray irradiation of mail in Washington, D.C., and its environs (not to mention other public health interventions made) were estimated to be in the billions of dollars.

—Eric A. Croddy

See also: Aum Shinrikyo; Biological Terrorism: Early Warning via the Internet; Vaccines

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BLEACH

Chlorine bleach (hypochlorite) has long been the workhorse for the decontamination of chemical or biological agents. There is, however, the possibility that bleach could be used as a lung irritant. This would involve the mixing of bleach with other chemical compounds, perhaps in some sort of chemical weapon that generates toxic by-products.

Incidents involving bleach and the production of toxic gas have mostly occurred in hazardous materials (HAZMAT) accidents and not through deliberate action. In some industrial settings—including hospitals that employ rigorous cleaning protocols—bleach and acidic compounds (e.g., phosphoric acid) are both used to ensure near-sterile conditions. On occasion, workers have been known to mistakenly mix the acidic solutions with the bleach, thereby creating chlorine gas. So much chlorine gas can be produced in this manner that deaths have resulted. In even more mundane settings, including the storage and use of civilian chemicals, the warning for citizens not to mix bleach with ammonia when cleaning their houses is especially well founded. Combining bleach with ammonia produces extremely toxic compounds called chloramines that can cause serious injury or death.

There has been one instance reported of a deliberate attempt to produce chloramine gas. During the 1980s, Dean Harvey Hicks had been protesting against the U.S. Internal Revenue Service (IRS). According to Hicks's federal indictment, part of his protest involved the placing of a car bomb near an IRS building. The trunk of his car contained two large containers: one holding bleach, the other, ammonia. Federal prosecutors claimed that Hicks intended the car blast to mix the chemicals together to produce a toxic gas cloud. The explosives, however, did not detonate as planned.

Use in Decontamination

As an oxidizing agent—in simple terms the chemical addition of oxygen—bleach is effective in the neutralization of most known chemical warfare agents, although its role in decontamination must be weighed against its irritating effects on the skin and the damage it can do to some materiel. A Chinese military manual on chemical weaponry describes the action of bleach on sulfur mustard, a blister agent (vesicant): "For example mustard, after coming into contact with bleach [calcium hypochlorite] can cause a reaction, the mustard gas being oxidized by the bleach, the bleach itself being reduced, and the mustard is then transformed from its original nature, losing its toxicity" (Cheng and Shi, p. 73).

As evinced by its widespread use in community water treatment, bleach is particularly effective in the denaturing of microbial threats, including bacteria and viruses as well as protein-based toxins. (The defensive mechanism in human cells utilizes the oxidizing power of hypochlorite when dealing with pathogens, for example.)

In military settings, calcium hypochlorite and a mixture known as Super Tropical Bleach have been standard items in the decontamination arsenal. For the U.S. military, however, a less toxic alternative was introduced in 1999 in the form of the Improved Chemical Biological Agent Decontaminant/Decontaminating Agent: Multipurpose (ICBAD/DAM). Still, for maintaining areas where contaminated casualties are handled or infectious materials are disposed of, regular bleach is still employed because of its effectiveness and relatively low cost. The Chinese military recommends what it calls three-and-two mix, containing three parts calcium hypochlorite and two parts calcium hydroxide. Although they are quite effective for decontaminating surfaces, only very dilute solutions of these extremely caustic compounds should be used for the human skin.

—*Eric A. Croddy*

See also: Decontamination

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BLOOD AGENTS

Often referred to as "systemic poisons" due to their perceived route of action, hydrogen cyanide, carbon monoxide, and phosphine and arsine gases, inter alia, have been traditionally referred to as blood agents. These toxic chemicals (such as cyanide) were noted to have affected not a single part of the body, but its whole. Writing in 1937, Augustin Prentiss noted: "The systemic toxic agents are those compounds which, instead of confining their dominant action to some particular organ or part of the body, usually near the point of impact, have the power to penetrate the epithelial lining of the lungs without causing local damage. They then pass into the bloodstream, whence they are diffused throughout the whole interior economy of the body and exercise a general systemic poisoning action which finally results in death from paralysis of the central nervous system" (Prentiss, p. 170).

The term *blood agents* is both anachronistic and a misnomer. Nonetheless, because of its widespread use in military parlance (if not in actual warfare), the term is used here simply out of convention.

Carbon Monoxide

One potential chemical warfare (CW) agent, carbon monoxide, could truly be called a blood agent by dint of its action on hemoglobin, the oxygen-carrying protein found in red corpuscles. Because carbon monoxide's binding affinity with hemoglobin is about 250 times more than oxygen's, low concentrations of carbon monoxide are capable of causing death by asphyxia. Coal-based heating systems with inadequate ventilation are responsible for many deaths every year due to carbon monoxide poisoning, and a common method of suicide is to leave an automobile engine running in an enclosed area, exposing oneself to the carbon monoxide in the car's exhaust.

Carbon monoxide has features that make it appear to be a plausible weapon of mass destruction. It has a moderate toxicity: death can occur following a 5- to 10-minute exposure to 0.5 percent concentration by volume. Being odorless, carbon monoxide also is insidious. However, carbon monoxide is gaseous at room temperature and dissipates far too quickly for efficient use on the battlefield. Terrorists could possibly find enough carbon monoxide on the open chemical supply market and mount an attack by directing the gas into large, enclosed spaces. Still, as a practical matter, it is difficult to conceive of using this compound in such a way that would produce mass casualties.

Carbon monoxide has rarely been used as a CW agent, at least not purposefully. Nonetheless, because conventional explosives can produce (among other gases) carbon monoxide, deaths due to asphyxiation following detonation of a shell could occur, especially in tight spaces. During the Korean War (1950–1953), Soviet advisors looked into allegations that the United States was using chemical weapons against North Korea and the Chinese People's Volunteer Forces. They determined that at least some of the deaths they examined were caused by carbonic gas (i.e., CO_2) from a large-caliber shell that had detonated inside a tunnel with inadequate ventilation. It is likely that carbon monoxide could have been responsible as well.

After World War I, French and German military chemists employed carbon monoxide in some fashion as a CW agent. One formulation that had some promise was a mixture of another blood agent, hydrogen cyanide (see below), with metal carbonyls. These are metallic compounds containing five units of carbon monoxide in each molecule, such as iron pentacarbonyl [$Fe(CO)_5$]. Although the metal carbonyls have a certain degree of toxicity, they also readily decompose and liberate carbon monoxide. Germany possessed a limited number of chemical munitions using carbonyls in tandem with other agents (such as phosgene) during World War II. Under the right circumstances, not only could these produce lethal concentrations of asphyxiating gas, but the use of carbonyls could also overcome the utility of protective mask filters used at that time, as they did not afford protection against carbon monoxide. As there are no indications that Germany used such munitions in World War II, however, no data are available as to their actual effectiveness.

Cyanide

Cyanide and related compounds have been recognized for centuries as toxic substances. In 1782, the Swedish chemist Karl Wilhelm Scheele first described the chemical formula for hydrogen cyanide (or hydrocyanic acid). Although the exact cause is not known for certain, it is widely believed that his sudden death in the laboratory four years later was as a result of working with this compound. According to one account, in 1813 a pharmacist suggested to the Prussian General Bülow that cyanide could be used on bayonets. (A similar story is told concerning Napoleon III having gotten this idea during the Franco-Prussian War.) In World War I, France was equipped early on with cyanide-filled artillery munitions. It did not use them right away, possibly out of concern that using chemicals by means of projectile weaponry was in violation of the Hague Convention (1899). Following the major gas (chlorine) attack by Germany at Ypres in 1915, however, such reservations quickly seemed irrelevant.

In 1988, some 5,000 civilians were massacred by a chemical weapons assault—including nerve and mustard—at Halabja in northern Iraq. This was a largely Kurdish-populated village that had invoked the wrath of Saddam Hussein's military during the Iran-Iraq War (1980–1988). Because of the placement and condition of the casualties seen in photographs following the chemical attack, some U.S. intelligence sources and media claim that hydrogen cyanide may have been involved. Such reports, however, are unsupported by strong corroborating evidence.

Today, because of its use in the chemical industry (e.g., in the production of acrylonitrile, a widely used polymer for plastics) and its potential diversion from the market for use in CW, hydrogen cyanide is designated as a Schedule 3 chemical for regulation by the 1993 Chemical Weapons Convention.

Still used in a variety of commercial applications, cyanide was once widely found in pesticide formulations to kill rodents, especially in barns and other large structures such as naval vessels. Before World War II, Germany employed the so-called cyclone method, using hydrogen cyanide adsorbed onto wood chips or another material. Held in canisters, their contents would be released when ready for use. In the interest of safety, this "Zyklon" rodenticide also employed a very noticeable warning odor, often imparted by chloropicrin or another substance that is immediately irritating to the nose. Zyklon B—commercially produced in Nazi Germany—was employed to massacre millions of Jews during the Holocaust. Needless to say, this preparation had no telltale odor in it to warn its human victims.

The toxicity of cyanide is chiefly due to its inhibition of an enzyme critical to the body's uptake of oxygen and energy for cellular metabolism, cytochrome oxidase. Its ability to suddenly block transmission of energy in the body has been likened to shutting off a water hose. East German military chemist Siegfried Franke has described the physiological effects of cyanide in humans: "Depending on the concentration, death from hydrocyanic acid intoxication occurs in 15 to 20 minutes; concentrations of 0.4 mg/liter are unconditionally lethal. With higher concentrations those affected fall dead immediately, or they stumble, struggle for air, and start to scream, the scream ending in a rattle. They fall to the ground and die after 3 to 5 minutes after a brief phase of convulsive movements. The color of the skin of the victims is red to violet" (Franke, p. 179).

East German and Chinese references also describe widened pupils as being symptomatic of cyanide poisoning, but U.S. literature downplays the significance of this symptom. Some important idiosyncrasies about hydrogen cyanide (HCN) and its effects are also worth mentioning here. HCN is often described as having a metallic odor reminiscent of almonds. Dangerous concentrations of HNC, however, are reported to dull the olfactory senses. Also, depending upon which source is referred to, it is estimated that up to half of the world's population is genetically indisposed to detecting the odor in the first place.

Hydrogen Cyanide

Of all of the recognized blood agents, hydrogen cyanide is probably the most likely chemical agent for use in warfare or terrorism. Still, HCN suffers from many of the disadvantages of carbon monoxide and other highly volatile compounds. It is liquid at room temperature, but just barely. HCN volatilizes so quickly that it can leave behind a congealed spot due to rapid dissipation of heat. Maintaining the concentration necessary to cause death (some twenty-five times that necessary with a nerve agent such as sarin) is a difficult task and was a technical problem that was never really solved during World War I. For example, Franke reports that France used some 4,000 tons of HCN in chemical attacks during that conflict—all with no appreciable result. This, Franke notes, would have "sufficed to kill about a billion people under the liquidation system of Himmler's death factories" (Franke, p. 176). With the advent of the highly toxic organophosphate nerve agents (e.g., sarin), HCN has fallen even lower in usefulness as a potential war gas.

Making the process of weaponizing HCN even more problematic is its notorious instability. Left to its own devices, HCN will spontaneously polymerize—reacting with itself chemically in a violent explosion. Metals, including cobalt and nickel in oxalate salts, have been used in attempts to stabilize this compound. During World War II, some Japanese soldiers were equipped with glass jars filled with liquid HCN that had been chemically stabilized with copper or arsenic trichloride. Although some were thrown at British tanks during World War II, it is unknown if any Allied soldiers were killed by these gas grenades.

Other nations, including the United States, Germany, and the Soviet Union, also spent much effort to find methods of effective HCN delivery. Though most of these attempts ended in failure, some aerial dissemination techniques were developed that could have had potentially devastating impact on the battlefield. During World War II, German military intelligence reported that ongoing Soviet trials, using HCN delivered at low altitude and from slow-moving aircraft, were apparently successful in creating lethal concentrations over large areas. The trick here, apparently, was to conduct these air sorties at sufficient heights and speeds to avoid being shot down by antiaircraft guns.

Terrorists might at some point attempt to devise means of delivering HCN, either in its original form (perhaps having been acquired through the chemical industry) or by producing it in vapors from a reaction between cyanide salts with acid. In 1995, Aum Shinrikyo cult operatives shut down the Tokyo subway by releasing sarin nerve agent, killing 12 and injuring about 1,000 people. Not long afterward, binary devices were discovered in subway restrooms. These contained one container full of cyanide salt, the other of dilute sulfuric acid, and they were rigged to combine their contents by means of a timer. The binary cyanide devices were discovered before they could do any harm, but they clearly demonstrated how terrorists could deliver HCN by using simple chemistry. According to witness accounts and intelligence reports, it is quite likely that al-Qaeda terrorist operatives have experimented with using such compounds. Video footage seized in Afghanistan in 2002, for example, showed what appeared to be al-Qaeda members using a compound that has similar properties to HCN in tests using dogs. Because sodium and potassium cyanide are sold worldwide in quantities of thousands of tons, particularly for the gold mining industry, there is no lack of precursor material. (As a consequence, the Australia Group lists both of these salts in the category of its voluntary controlled chemical lists.)

If medical intervention is timely, humans can survive even multiple lethal doses of HCN poisoning. Antidotes prescribed for cyanide poisoning vary depending upon the country. Generally speaking, the formation of methemoglobin from hemoglobin in the blood—the latter instrumental for carrying oxygen through the body—by sodium nitrite (or amyl nitrite) helps to scavenge cyanide from cytochrome oxidase, increasing the victim's chances of survival. Sodium thiosulfate is used to further remove cyanide from the body by means of other enzyme reactions (by combining free cyanide with sulfur to form relatively harmless thiocyanate). Modern protective masks also help to decrease the risk of cyanide exposure by means of a chemical barrier such as chromium (oxidation state VI), or preferably zinc, as inhaled Cr VI has toxic properties.

Cyanogen Chloride (CN)

Much of the toxic nature of HCN is also found in cyanogen chloride (CNCl), although the lethal concentration of cyanogen chloride is reported to be about double—that is, CNCl is about half as toxic—as HCN. The immediate effects of cyanogen chloride are quite noticeable, especially in the mucosa, with a very strong irritating effect on the eyes and upper respiratory tract. In World War I, the French military utilized a mixture of HCN and cyanogen chloride, called manguinite. The goal was to create such an irritant to enemy troops that they would remove their protective masks, allowing HCN to finish them off. Cyanogen chloride, and related compounds such as the bromide form, held some promise for U.S. military use in World War I, but these compounds were also quite unstable due to spontaneous polymerization.

Other Systemic Poisons

Two other compounds, arsine and phosphine gas (in older literature referred to as arseniuretted hydrogen and hydrogen phosphide, respectively), were investigated during World War I as potential CW agents. Phosphine has been used as a rodenticide, and arsine is also toxic, but neither proved to be very effective as CW agents. Some work was performed in the area of forming binary devices to use with these chemicals, however, possibly during World War II. According to Chinese military CW specialists, an unnamed country "experimented with an aerial bomb, one with a separate chamber containing magnesium arsenide and another holding sulfuric acid. When the bomb was to hit the ground, a firing pin broke a membrane separating the two components. When they mixed, a chemical reaction produced the blood agent arsine" (Cheng and Shi, p. 27).

Tetraethyl lead and related compounds can act as a nerve-acting poisons, probably affecting the brain stem, resulting in convulsions and death. Decades ago, tetraethyl lead was commonly added to automobile gasoline as an antiknock agent. Some catastrophic accidents in the 1920s underscored the fact that this was an extremely toxic compound, so much so that Germany's stocks of tetraethyl lead were scrutinized after World War II out of fear about their potential use as chemical weapons. Nowadays, its use in automobiles has largely waned, and it is no longer considered a likely CW agent.

—Eric A. Croddy

See also: Binary Chemical Munitions; Vincennite

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BOTULISM (BOTULINUM TOXIN)

Due to the extreme toxicity of botulinum toxin, it was one of the first agents to be considered as a biological weapon. In a list compiled by the U.S. Centers for Disease Control and Prevention (CDC) that includes bacteria, viruses, and toxins thought to pose the greatest risk for use in a bioterrorist attack, *Clostridium botulinum* falls under Category A—that is, the level of highest immediate risk. Clostridial neurotoxins are among the most toxic substances known to science. Their inclusion as a high-risk agent in bioterrorism is due not only to the very high toxicity of botulinum toxin, but also to its past development as a weapon and its relative ease of production. Clinically, botulinum toxin has been estimated to be lethal at very small doses for the average adult when ingested. When aerosolized, the lethal dose when inhaled is approximately five times larger than the lethal does when ingested.

Botulism is a disease that paralyzes muscles due to a toxin produced by the bacterium *Clostridium botulinum.* The main categories of botulism in the context of infectious disease are those of food-borne illness (particularly among infants) and complications arising from wounds that become contaminated with *Clostridium botulinum* spores.

Food-borne botulism usually occurs when a person ingests the causative bacteria and/or the botulinum toxin, leading to illness within about 24 hours. Until the ultimate source is found, such individual cases are considered a potential public health emergency, as many other people could be affected as well, depending on the food source. Infant botulism occurs in a small number of children, probably because their digestive tracts at their early stage of growth are more susceptible to ingestion of *C. botulinum* (this is the concern that has prompted warnings against feeding honey to infants, as sometimes *C. botulinum* spores are found in honey). Wound botulism takes place when wounds are infected with *C. botulinum*—found in soils and other materials in the environment—and the bacteria then secrete toxin (note that the source of tetanus, *Clostridium tetani,* similarly infects wounds in this fashion). (For more about these three forms of botulism, see below.)

Botulism is not spread from one person to another. Symptoms of botulism include double vision; blurred vision; drooping eyelids; slurred speech; difficulty swallowing; dry mouth; and muscle weakness (flaccid paralysis) that starts at the shoulders, spreads to the upper arms, and descends through the body. In the instance of paralysis of the breathing muscles, an individual can stop breathing and die unless assistance with breathing (mechanical ventilation) is given. If administered early in the course of the disease, the antitoxin is effective in reducing the severity of symptoms. Most patients eventually recover after weeks to months of supportive care.

History

The U.S. military began a concerted offensive biological warfare program in 1941, proceeding to develop biological weapons over the next 28 years. During World War II, the United States worked primarily on botulinum toxin and anthrax bacteria while also studying other diseases for warfare such as brucellosis, psittacosis, tularemia, and glanders. During World War II, intelligence information indicated that Germany was attempting to develop botulinum toxin as a weapon to be used against Allied invasion forces. At the time the Allied work to defend against this threat began, the composition of the toxic agent produced by *C. botulinum* was not clear, nor was the mechanism of lethality in animals and humans. Therefore, the earliest goals of research on botulinum toxin were to isolate and purify the toxin and to determine its pathogenesis. As it happened, there was apparently no effort on the part of German military scientists to utilize botulinum toxin against potential invasions. But due to this early intelligence—and due to strict rules regarding the compartmentalization of this intelligence—the Allies produced some 300,000 doses of botulinum toxoid (vaccine) for D-Day troops in 1944. None of these doses were administered.

One of the more lasting legacies of the early botulinum toxin biowarfare research was the development of the botulinum vaccine that is used today. It was clear that the scientists working with large quantities of the toxin needed to be protected from possible laboratory exposures and that a vaccine would serve them as well as the armed forces at risk of biological warfare attack. A formaldehyde-inactivated toxoid (i.e., a toxin that has been treated so as to destroy its toxicity but retain its antigenicity) proved effective in animal studies, and large quantities were prepared for human use. Many humans have since been vaccinated with this and similarly prepared botulinum toxin vaccines, and clinical experience has indicated that the vaccines are safe and effective.

In 1992, Russian President Boris Yeltsin admitted to a biological warfare program that had existed in the Soviet Union and Russia until early 1992, and he stated that he was putting an end to further offensive biological research. Botulinum toxin was one of several agents tested at the Soviet site code named Aralsk-7 on Vozrozhdeniye Island in the Aral Sea. A former senior scientist of the Russian civilian bioweapons program reported that the Soviets had attempted splicing the botulinum toxin gene from *C. botulinum* into other bacteria.

Four of the countries listed by the U.S. government as "state sponsors of terrorism" (Iran, Iraq, North Korea, and Syria) have developed, or are believed to be developing, botulinum toxin as a weapon. Of these countries, Iraq has been the greatest source of concern. After the 1991 Persian Gulf War, Iraq admitted to the United Nations inspection team that it had produced 19,000 liters of concentrated botulinum toxin, of which approximately 10,000 liters were loaded into military weapons. These 19,000 liters of concentrated toxin are still not fully accounted for, and theoretically they constitute approximately three times the amount needed to kill the entire human population on Earth. Iraq chose to weaponize more botulinum toxin than any of its other known other biological agents. Following the invasion of Iraq in 2003, Coalition forces failed to find large quantities of botulinum toxin in Iraq.

Chemical Properties

C. botulinum is a gram-positive (classification of bacteria that absorbs gram stain), obligate anaerobic (requires environments without oxygen), spore-forming, rod-shaped bacterium found worldwide in soils and marine sediments. Because it is found in the soil, it can contaminate vegetables. It also colonizes the gastrointestinal tracts of fish, birds, and mammals. Botulism and botulinum toxin are not contagious and cannot be transmitted from person to person. Food poisoning due to botulinum toxin particularly emerged as a problem when food preservation became a widespread practice. It is now clear that *C. botulinum* grows and produces neurotoxin in the anaerobic conditions frequently encountered in the canning or preservation of foods. The spores are very hardy, and special efforts in sterilization are required to ensure that the organisms are inactivated and unable to grow and synthesize their toxin. Modern commercial procedures have virtually eliminated the problem of food poisoning by botulinum toxin (through pasteurization), and most of the cases now seen are associated with home-canned foods or with meals produced by restaurants not adhering to safe food handling practices.

Seven distinct serotypes (classification within species of pathogens based on immune response) of botulinum toxin have now been isolated, designated A through G. It is interesting that not all serotypes have been associated with poisoning of humans. Serotypes A, B, E, and F have been clearly identified in numerous human poisoning episodes. Serotype G is the most recently isolated toxin and has only been identified in a few outbreaks. For serotypes C and D, only a single anecdotal case of human poisoning has been reported for each. These serotypes have been found in outbreaks involving various animals, including chickens and minks in domestic settings and ducks in wild environments. It is not clear why humans are typically not poisoned by serotypes C and D.

Although the seven neurotoxins (A, B, C, D, E, F, and G) are genetically distinct, they possess similar molecular weights and have a common subunit structure. The complete amino acid sequences of the various serotypes are becoming known. Regions of sequence homology (sameness) among the serotypes and between botulinum toxins and tetanus toxin suggest that they all employ similar mechanisms of action. In the case of botulinum toxin, nerve cells are prevented from secreting acetylcholine—a neurotransmitter that allows for nervous impulses to be transmitted in the body—due to the inhibition of proteases, enzymes that break cell walls to allow for secretion of acetylcholine in this case. Thus, botulinum toxin serves as a means to prevent nerve impulses from actuating or enervating nerve cell transmission, a reverse of the activity done by the anticholinesterases (nerve agents).

Other Varieties of Botulism

Apart from the main forms of botulism, that is, food-borne, wound, and infant, the two other clinical categories are adult infectious and inadvertent (following botulinum toxin injection) botulism.

Food-Borne Botulism. Onset generally occurs 24 to 36 hours after exposure. Initial symptoms can include nausea, vomiting, abdominal cramps, or diarrhea. After the onset of neurological symptoms, constipation is typical. Dry mouth, blurred vision, and diplopia (double vision) are usually the earliest neurological symptoms. They are followed by dysphonia (difficulty in speaking), dysarthria (loss of muscle control in joints, including slurring of words), dysphagia (difficulty in swallowing), and peripheral muscle weakness. Symmetric descending paralysis as described above is characteristic of botulism.

Wound Botulism. This can be defined as clinical evidence of botulism following lesions with a resultant infected wound and no history suggestive of food-borne illness. Except for the gastrointestinal symptoms, the clinical manifestations are similar to those seen in food-borne botulism. However, the incubation period is much longer because time is required for the incubation of spores, growth of the bacteria, and release of toxins (taking 4–14 days).

Infant Botulism. This is caused by the absorption of toxin produced by *Clostridium botulinum;* the organism can colonize the intestinal tracts of infants under 1 year of age, but occasionally it also colonizes the tract in adults (rare). It is often associated with ingestion of honey, and the first clinical sign is usually constipation. After a few weeks, progressive weakness and poor feeding are observed. The weakness is symmetrical and descending; it evolves over hours or several days. The infant has a weak cry, has either absent or diminished spontaneous movements, and shows decreased sucking, floppy head, and decreased motor responses to stimuli. The autonomic nervous system manifestations include dry mucous membranes, urinary retention, diminished gastrointestinal motility, fluctuation of heart rate, and changes in skin color. Hospitalization is necessary and may last from a few days to 6 months.

Botulism as an infection in adults occurs as a result of intestinal colonization with *C. botulinum* and toxin production in a manner similar to that of infant botulism. These patients often have a history of abdominal surgery, achlorhydria (lack of necessary hydrochloric acid in the stomach), Crohn's disease (a chronic disease of the digestive system), or recent antibiotic treatment. The disease may simulate a Guillain-Barré Syndrome (a neurological disorder typified by weakness of the peripheral muscular-nervous system).

Medical Response to Botulism

There are two basic alternatives for prophylaxis from botulinum poisoning: active immunization using a vaccine (toxoid), or passive immunotherapy using immunoglobulin, an antibody that helps to neutralize the toxin. The vaccine currently available is a toxoid that protects from serotypes A through E. This material is being used under Investigational New Drug (IND) status, from a license held by the CDC in Atlanta. The toxoid was developed by scientists at Fort Detrick in Frederick, Maryland, during the 1950s. It is a formalin-fixed crude culture supernatant—meaning the toxin produced from the culture is made nontoxic with the addition of formaldehyde for use as a toxoid—from strains of *C. botulinum* that produce the respective serotypes. Vaccinations are administered at 0, 2, and 12 weeks, followed by annual booster doses.

In addition to a recombinant vaccine, that is, a vaccine produced in genetically modified organisms presently in development, research on cocktails of better and more specific (monoclonal) antibodies is being conducted at the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) at Fort Detrick, to replace the antibody from horse serum. The latter is despeciated horse serum. The antibodies produced by the horse are cleaved by special enzymes to avoid side effects (serum sickness) posed by horse-specific proteins. This antibody, while an improvement over previous antibody preparations, could stand further refinements. Thus the more specific and pure monoclonal antibody approach will enhance the safety of the immunotherapy, and recombinant techniques could also reduce the cost of therapeutic antibody.

Botulism can thus be prevented by the presence of a neutralizing antibody in the bloodstream. Passive immunity can be provided by the horse-derived botulinum antibody or by specific human hyperimmune globulin, antibodies from human sera. For longer term immunity, immunization with botulinum toxoid is required. Use of antibody for postexposure prophylaxis is limited by a lack of antibody and its relatively high risk of side effects. Due to the potential risks of equine antitoxin therapy, it is not always certain how best to care for persons who may have been exposed to botulinum toxin but who are not yet ill. In order to achieve a balance between avoiding the potential adverse effects of equine antitoxin and needing to neutralize the toxin rapidly, it is current practice in food-borne botulism outbreaks to closely monitor persons who may have been exposed to botulinum toxin and to treat them promptly with antitoxin at the first signs of illness.

In the United States, an IND for use as vaccine containing a pentavalent (addressing five of the serotypes, A–E) botulinum toxoid is supplied by the CDC to laboratory workers at high risk of exposure to botulinum toxin and by the military for protection of troops against attack. Currently, however, preexposure immunization is neither recommended for, nor available to, the general population.

Botulinum toxin ("Botox") is the first microbial toxin to become licensed for treatment of human disease. In the United States, it is currently licensed for treatment of cervical torticollis (muscular disorder of the neck), strabismus (crossed eyes), and blepharospasm (involuntary blinking) associated with dystonia (the general term for the neurological condition typified by involuntary muscular contraction). It also is used "off label" for a variety of more prevalent conditions including migraine headache, chronic low back pain, stroke, traumatic brain injury, cerebral palsy, and achalasia (muscular disorder of the esophagus). More recently, the medication Botox has been used as a means to decrease facial wrinkles by paralyzing certain facial muscles.

—*Kalpana Chittaranjan*

See also: Bioterrorism; Toxoids and Antitoxins; World War II: Biological Weapons

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BRUCELLOSIS (*BRUCELLA* BACTERIUM)

A gram-negative (bacterium does not absorb gram's stain) coccobacillus (a short rod-shaped bacterium), *Brucella* comprises at least four types of bacteria that cause brucellosis in humans but is found nowadays mostly in domesticated and wild animals: *Brucella suis* (swine), *Brucella melitensis* (sheep), *Brucella abortus* (cattle), and *Brucella canis* (dogs). Named after David Bruce, who isolated the organism, brucellosis has been called Malta fever (it was widespread among British soldiers stationed there during the Crimean War), Mediterranean gastric remittent fever, or undulant fever. *Brucella* bacteria can infect humans by means of ingestion of contaminated milk or meat, as well as through broken skin. Workers in slaughterhouses have often acquired brucellosis due to contact with diseased animals and infectious aerosols. It is not surprising, therefore, that *Brucella* would be researched for their potential use in warfare.

As a BW agent, *Brucella* bacteria are notable for being among the first to be weaponized in a modern U.S. military program. The *Brucella* bacterium, however, is best described as an incapacitant (versus a deadly pathogen), because in this antibiotic era, the lethality of brucellosis is quite low (5 percent mortality or less without treatment). Both the United States and the former Soviet Union prepared *Brucella* bacteria for use in biological weapons. Later, both countries replaced this organism with other BW agents that proved more reliable.

History

In March 1944, according to the official history of the U.S. biological weapons program, the U.S. Chemical Warfare Service (CWS) undertook investigations into *Brucella* as a potential BW agent. (Other sources suggest that the utilization of *Brucella* bacteria was actually proposed two years earlier.) Although clinically, the bacterial species *Brucella melitensis* is most often associated with serious human infection, it also proved more difficult to grow and to keep virulent. Animal experiments conducted at that time using Guinea pigs also showed that much fewer *Brucella suis* bacteria were required to cause infection when disseminated as an aerosol. Thus, during World War II, the U.S. Army selected *Brucella suis* for weaponization.

Pilot production of bacteria commenced in summer 1945 at Camp Detrick, Maryland (later named Fort Detrick), after infecting laboratory animals and harvesting their bacteria-laden spleens. Bacteria were then added in small amounts and then gradually to larger vessels containing growth media, demonstrating the viability of large-scale production of *B. suis* bacteria with reasonable standards of quality and safety. It was also shown that bacteria could be grown and collected in a concentration of about 4×10^{10} organisms per ml, "which was acceptable as filling for munitions" (Cochrane, p. 270), according to the U.S. history of the program. Production of *Brucella* was halted in September 1945.

At the end of World War II, the technology of the day was limited to liquid suspensions of *Brucella*, with refrigeration offering the primary means of maintaining live bacterial cultures for weapons fill. Thus, when it came to a practical design for biological munitions, this organism was problematic as a weapon. When compared to other organisms such as anthrax, however—and even though *Brucella* bacterial cells do not form hardy spores—the organism performed rather well during aerosol tests. A cryptic reference to additional studies—the results being "both negative and faulty" (Cochrane, p. 270)—on the transmission of *Brucella* by canaries suggests that even more novel methods of disseminating this bacterium were investigated.

In 1949, a year before the outbreak of the Korean War, the U.S. Army Chemical Corps selected *B. suis* as the first standardized biological weapon in the American arsenal. In 1950 and 1951, preliminary tests using aerial munitions dropped from B-29s were conducted at Dugway Proving Ground, Utah. Validating field trials in 1952 eventually gave way to the first standardized biological weapon in the U.S. arsenal. This consisted of M114 bombs (108 of them) that were clustered in formation with the M26 adapter, and the weapon was named the M33 *Brucella* cluster bomb. It was provided to the U.S. Air Force. Up to sixteen of these clustered munitions were deemed necessary to cover a square mile of territory. Each M33 package weighed approximately a quarter ton. Because the bacteria required refrigeration, the ordnance proved to be a logistical nightmare. It was never used in battle.

***Medical Characteristics of* Brucella**

In an aerosol, *Brucella* bacteria are among the more infectious, requiring only 10 to 100 bacteria to cause disease in humans. There is some risk in developing countries from infection of food or beverages, the classic means of acquiring infection being from unpasteurized milk or tainted meat by-products. Its low virulence and the existence of a wide spectrum of antibiotics mitigate against a modern threat from brucellosis as a weapon. Its effects also are widely variable. Some people may be exposed but remain nonsymptomatic, but others may develop symptoms over 5 to 60 days after exposure.

Like other bacterial diseases found in BW contexts, brucellosis infection starts as a flulike illness, with fever, headache, chills, and general malaise. Up to three-fourths of victims may develop gastrointestinal upset, with nausea, vomiting, and/or diarrhea. In a small number of cases, infection of the heart and nervous system can result in very poor outcomes. Endocarditis, albeit a rare condition, has been responsible for 80 percent of the deaths that have occurred as a result of *Brucella* infection. With a predilection for disease of skeletal joints during its course, brucellosis can also lead to arthritis in more than 30 percent of cases. Transmission from person to person is not likely during the infectious stage of the disease. However, because of the capacity for aerosol transmission, laboratories should have in place relatively high containment standards, at least biosafety level 3 (BL-3) when handling the organism, one step below the highest containment measures (BL-4). Treatment of brucellosis involves antibiotic therapy, with doxycycline plus rifampin being recommended, or doxycycline and streptomycin as an alternative. Although (live) vaccines are used for animals, no prophylactic treatment is currently available for human use.

When compared to other BW threats such as anthrax, brucellosis is not expected to top the list of bioterrorist or BW threats for the modern battlefield. However, its endemic nature as a zoonotic in some regions of the globe may present a public health threat for operations conducted overseas. Also, one cannot rule out the possibility of the use of *Brucella* as an antianimal disease to cause disruptions in the agricultural sector.

—*Eric A. Croddy*

See also: Agroterrorism; Korean War; United States: Chemical and Biological Weapons Programs

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BURKHOLDERIA MALLEI

See Glanders

C

C-4

During World War II, the British military had developed a high explosive that could be safely handled and shaped—thus the moniker "plastic explosive." One formulation contained RDX (Royal demolition explosive) and an oil-based plasticizer, the resulting product being dubbed "Composition C" by the United States. Later, a need was found for a plastic explosive that did not harden at low temperatures. A composition that used about 90 percent RDX, and small amounts each of polyisobutylene, motor oil, and another inert substance, was called C-4. Since its first development, C-4 explosive has found multifarious uses in military and civilian applications. Terrorists also seek out C-4 and high explosives of similar specifications.

—Eric A. Croddy

See also: TNT

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CARBAMATES

The toxic carbamates are compounds sometimes equated with nerve agents. They get their name from their general structure, which is based on carbamic acid. These compounds can inhibit the body's enzymes (cholinesterases) that regulate neurochemical transmission. As in the case of the toxic nerve agents that contain phosphorus, carbamates probably bind at or near the same site of the enzyme's molecule, blocking its normal activity. When the body is no longer able to split apart the neurotransmitter acetylcholine, there is runaway chemical stimulus at the nerve receptors. This results in an imbalance in the body's nerve impulses, possibly resulting in death; carbamates could thus be technically considered nerve agents. Carbamate compounds, however, have not been developed as a weapon of mass destruction (WMD) as have the organophosphate nerve agents. Typically, carbamates act as so-called reversible inhibiters of cholinesterase, and therefore their poisonous effects are milder and more transient than those of the more toxic nerve compounds. Some carbamates are highly toxic in mammals, however, including one compound estimated to be 30 times more poisonous than sarin.

Applications for carbamates include the agrochemical industry (insecticides), medical applications (e.g., treatment of myasthenia gravis, an autoimmune disorder that affects nerve receptors), and defensive prophylaxis for nerve agent poisoning (see below). In the civilian chemical industry, Sevin(r) (or carbaryl) has been one of the most widely used of the carbamate insecticides, and it is not very toxic in mammals. Unfortunately, the mass production process used for this insecticide sometimes involves a reaction between methyl isocyanate and naphthalene. Due to what was probably insider sabotage at the Union Carbide plant in Bhopal, India, a massive release of methyl isocyanate killed thousands of people in the early 1980s (*see* Bhopal, India: Union Carbide Accident). Another carbamate, Aldicarb, is a commonly used insecticide, but it has relatively high mammalian toxicity for both oral and dermal routes. For experimental animals (e.g., rodents), the average lethal dose of Aldicarb is hundreds of times lower (meaning that Aldicarb is hundreds of times more toxic in mammals) than Sevin. In the potential application as a weapon of mass destruction, it is possible that terrorists could divert Aldicarb or other toxic compounds like it into some sort of improvised chemical weapon.

The toxic chemical in the calabar bean is physostigmine, a carbamate compound that was named in 1864. (A year later, other investigators also discovered the active ingredient, calling it eserine. Therefore, there are now two names for the same compound.) In western Africa, the calabar bean had been traditionally employed as a so-called ordeal poison for certain tribal deliberations and in witchcraft ceremonies. If someone were accused of a crime, for example, the subject would be given calabar beans to swallow, and if he or she survived, his or her innocence was supported. (One theory suggests that those who partook of the ordeal with calabar, if they were truly innocent, felt no compunction about proving it and gulped down the beans quickly. As a result, their now-upset stomach would induce vomiting, and the full dose of the toxin was not absorbed. Guilty subjects, however, would tentatively chew and eat each calabar bean one by one, ensuring that the full dose was ingested into the alimentary canal and intestinal tract. These subjects suffered severe poisoning and death.)

Carbamates have found a role in the medical pretreatment of exposure to nerve agents. In the United States and other Western countries, the pyridostigmine bromide (PB) has been used as a means to prepare the body to resist possible poisoning with nerve compounds such as soman (GD). Because PB is a reversible inhibitor of acetylcholinesterase (AChE), it can bind to the enzyme and protect it from permanent immobility from the irreversibly binding (and highly toxic) nerve agents. In the event of nerve agent exposure, the carbamate holds AChE enzyme in reserve, and eventually releases it back into the body to restore normal activity.

China has employed carbamates for nerve agent prophylaxis, using substances called *cuixing'an* and *cuixingning*. Chemical weapons experts in the Chinese People's Liberation Army claim that these compounds are more effective than PB in protecting troops from nerve agent intoxication, and this may well be the case. However, both cuixing'an and cuixingning would affect the central nervous system and could therefore degrade performance in soldiers. Pending full studies and safety evaluations, however, it is possible that these compounds might find their roles as pretreatment for nerve agent poisoning in the west.

During the 1991 Gulf War, Coalition forces were especially concerned about intelligence that indicated that Iraq intended to use soman nerve agent. (Fortunately, Iraq had difficulty in finding the chemical precursors to manufacture soman, which was later determined not to be in Iraq's chemical arsenal.) Because soman irreversibly binds to AChE, and furthermore does so in a very short time, PB was distributed to U.S. forces as a precaution in the event of an Iraqi chemical attack. There are conflicting accounts of how many U.S. soldiers actually took PB pills when ordered to, or what dosages were eventually consumed. In the early 1990s, PB was designated an Investigational New Drug for use against nerve agent exposure, and it was later approved by the U.S. Food and Drug Administration for such use in 2003. Claims made by some Gulf War veterans that PB is the source of health problems, namely the vaguely defined Gulf War Syndrome, are unfounded.

PB also is used in large doses for maintenance therapy in myasthenia gravis patients. Medical uses may be found for other carbamates such as applications for Alzheimer's disease, but these are only in the early research stages .

—Eric A. Croddy

See also: Agroterrorism (Agricultural Biological Warfare); Bhopal, India: Union Carbide Accident; Nerve Agents

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CENTERS FOR DISEASE CONTROL AND PREVENTION (CDC)

The Centers for Disease Control and Prevention (CDC) is the lead federal agency for protecting the health and safety of individuals in the United States and abroad. Located in Atlanta, Georgia, CDC is an agency of the U.S. Department of Health and Human Services. It provides information to enhance health decisions, and it promotes health through partnerships with forty-seven state health departments; twelve national Centers, Institutes, and Offices; and public health authorities in forty-five other countries. CDC's mission is to improve health and quality of life by preventing and controlling disease, injury, and disability. It accomplishes this mission by working with partners throughout the nation and the world to monitor health, detect and investigate health problems, conduct research to enhance prevention, develop and advocate sound public health policies, implement prevention strategies, promote healthy behaviors, foster safe and healthful environments, and provide leadership and training.

With heightened concern about the spread of emerging infectious diseases and the deliberate dissemination of biological warfare agents by rogue state and nonstate actors, CDC recently upgraded its efforts to fight against infectious diseases, with particular emphasis on emerging and antimicrobially resistant infectious diseases. It has prioritized international work to reduce and eliminate reemergent infectious diseases. And it continues to strengthen the capacity of local, state, and national public health agencies to respond to growing threats from biological and chemical terrorism. In 2003, CDC allocated more than $1 billion to improve the readiness of state and local health agencies to respond to events such as bioterrorism, infectious disease outbreaks, and other public health emergencies. CDC has prioritized improvements in the rapid detection of, investigation of, response to, containment of, and recovery from a terrorist attack or other public health emergency.

The CDC has categorized biological threat agents according to the overall impact in terms of illness and death, the relative ease of developing the agent as a weapon, the affect on the general public at large from a psychological perspective, and the flexibility of delivering the agent as a weapon (whether as an aerosol, food contamination, and so on.) The CDC considers the causative agents of smallpox, anthrax, plague, botulism, tularemia, and hemmorhagic fevers to be category A agents. Category B agents include causative agents of Brucellosis, salmonellosis, glanders, Q fever, ricin, and cholera, among others. Category C agents include emerging infectious diseases, such as Nipah and hantavirus, that could arise in the future to endanger public health if utilized by bioterrorists.

—Peter Lavoy

See also: Bioterrorism

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CHEMICAL AGENT MONITOR

The chemical agent monitor (CAM) is a detection device for toxic chemicals. The CAM and its successor, the improved chemical agent monitor (ICAM), grew out of defense research at Porton Down, U.K., during the late 1970s, and was later manufactured by Graseby Dynamics. (Similar versions are produced in the United States under license.) Although other detection devices exist that work along the same principles, the Graseby CAM is the preferred model in use by militaries and security forces around the world. Not only does it detect low levels of mustard (sulfur and nitrogen) and nerve (G-series and VX), but it also can indicate the approximate degree of contamination.

The essential part of this hand-held point detection device is a drift tube that detects ionized molecules of certain types and characteristics. Similar in some ways to a household smoke detector, air is brought into an inlet tube and passes near an ionizing source. As molecules from the air being sampled encounter either a radiation source (such as Americium or Ni^{63}) or an electric corona discharge (an electrical ionizing charge) in the device, these particles will become ionized. (Some countries such as Japan, because of local regulations concerning the use of radioisotopes, will only use nonradioactive ionization sources—that is, the electric corona version—for chemical weapons detection.) As the ions move down a drift tube, certain compounds arrive at the sensor in a sequence determined by their rate of travel. Should a nerve agent be present, its characteristic ion mobility will cause it to reach a sensitive electrode at a time and in a manner distinct from other chemicals in the air. This electrode will then send the signal to an amplifier, which in turn sends the signal to indicate a visual display or aural warning. Although some chemicals may confound this and other detection schemes, these devices are generally considered to be highly accurate and reliable when used correctly.

Early chemical agent point detectors, such as Russian and British CW agent alarms, monitored a chemical reaction created by the presence of a nerve agent. The 1968 vintage alarm standardized in the United States used an enzyme that, upon being demobilized by a nerve-type agent, sent an electric signal and warned the operator. Mustard gas was much less toxic and easier to detect in the field, notably by distinct odor. By the 1991 Gulf War, however, the U.S. and North Atlantic Treaty Organization militaries came to the realization that detection of both nerve agent and mustard in a single device was mandatory. A hurried requisition brought thousands of ICAMs from England that could detect the presence of both nerve agents and mustard. These devices have also been improved in terms of maintenance and reliability.

ICAMs are used "up close and personal" to the potential contaminated area when investigating possible chemical agent contamination, and they depend upon the volatility of CW agents for timely and accurate detection. Thus, low-volatility CW agents such as VX may be more difficult to detect in the field. It is generally considered necessary to be in full protective posture (such as U.S. MOPP IV—use of a protective suit and mask) when using an ICAM, the rationale being that the suspected presence of chemicals demands such precautions.

—Eric A. Croddy

See also: Protective Measures: Chemical Weapons

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CHEMICAL AND BIOLOGICAL MUNITIONS AND MILITARY OPERATIONS

When people speak of weapons of mass destruction, a common perception is of nuclear weapons within the Cold War arsenals of the Soviet Union and the United States, or within emerging nuclear weapon states. Chemical and biological weapons, however, are an emerging challenge of the twenty-first century. They are easier to produce than nuclear weapons, easier to hide from arms control inspection and verification measures, and in some cases they can be easier to deliver, especially when done by irregular means (i.e., terrorist groups). Yet, they can still produce mass casualties. Some biological weapons have the potential to produce casualties similar in scale to a large nuclear attack. In the context of the post–September 11 war on terrorism, chemical and biological weapons seem to be terrorists' weapon of choice because the technological complexity of nuclear weapons leaves them beyond the reach of most nonstate groups. Understanding the threat posed by chemical and biological weapons demands an understanding of the weapons themselves, including the different types, their effects, and how they would be used operationally, either by a state or a nonstate group.

Chemical Weapons

Chemical weapons employ toxic chemical agents, in either liquid or gaseous form, to either kill or incapacitate. The weapons vary in their lethality, in their persistency, and in how they enter the body and how quickly their effects are felt. The types of chemical agents available for use vary in effect, but they can be broken down into four main groups.

Nerve Agents

Nerve agents are the most lethal type of chemical weapon and include tabun, sarin, soman, and GF (NATO code for cyclosarin). The most lethal ones are VX and the new Russian novichok agents. Most nerve agents are clear, colorless liquids; sarin and VX are odorless as well. Nerve agents inhibit the functioning of the body's central nervous system, and they can cause death within minutes of exposure to an extremely small amount of agent. These agents can be inhaled or can penetrate the body through exposed skin. Inhalation of nerve agent leads to effects beginning within a few seconds to 1 minute, whereas penetration through the skin may result in effects emerging in anywhere from 30 minutes to several hours. The lethal dose varies with each agent, but with all nerve agents, the dose is very small.

Nerve agents, like all chemical weapons, have varying degrees of persistency, which is the amount of time that the agent remains lethal in an exposed environment. Tabun, for example, has a persistency of about 1 to 1.5 days, sarin only has a persistency of about 2.5 hours, and VX can remain persistent for up to 6 days. Thus, any materials contaminated by highly persistent agents can remain dangerous for a long time, requiring a military force to undertake nuclear/biological/chemical (NBC) protective measures, including the wearing of cumbersome NBC suits and respirators. The forces must also undertake ongoing extensive decontamination of personnel and equipment, all of which imposes severe logistical and operational challenges for a military force when they are being subjected to attack. In comparison, nonpersistent agents can be applied to a specific area, inflict heavy casualties, and then become inert after a few hours, allowing an enemy force to exploit the "cleared" area to break through.

Common symptoms produced by exposure to nerve agent poisoning include nausea and vomiting, dim or blurred vision brought about by contracted pupils, excessive nasal secretions and salivation, and constricted airways leading to shortness of breath. If a large amount were inhaled, or if no treatment were applied within minutes of exposure, then loss of consciousness would ensue, followed by convulsions, eventual cessation of breathing, and, ultimately, death. A nerve agent that penetrates through the skin as a liquid may lead to muscular twitching, and were a sufficiently large dose absorbed through the skin, the result would be convulsions, paralysis, loss of consciousness, cessation of breathing, and, ultimately, death within minutes.

During the late 1980s and early 1990s, a new class of nerve agents was produced by Soviet scientists. Known as novichok (or newcomer) agents, these came in a variety of forms. These may have been designed as binary agents made up of two harmless chemicals that, when combined, become a lethal chemical weapon. The novichok agents are reportedly as lethal as VX and, in some cases, up to ten times as lethal. They are also far more difficult for current chemical agent detectors (CADs) to detect on the battlefield, and they are resistant to nerve gas antidotes such as atropine. This makes their use on the battlefield much more effective, even if an opponent is equipped with modern NBC defensive measures. Furthermore, because they are binary agents, they can easily be produced covertly within civilian chemical facilities, and thus are ideal for circumventing the 1999 Chemical Weapons Convention (CWC).

Pulmonary Agents

A second group of chemical agents, known as pulmonary agents or choking agents, are designed to attack the respiratory systems of victims. If inhaled, these agents attack the membranes of the lung, filling the lungs with fluid and preventing air from entering. The victim then dies from a form of suffocation described as dry-land drowning. Both phosgene and chlorine are pulmonary agents and were used during the First World War, but they are no longer considered very effective because they evaporate quickly and can only be effective if inhaled. NBC protective measures such as respirators can fully protect against such agents.

Vesicant Agents

Vesicant agents (also referred to as blister agents) produce similar effects to pulmonary agents, but they also affect both the skin and eyes through

Modern militaries constantly train and prepare in the event of a chemical or biological attack. (Hulton-Deutsch Collection/Corbis) burning. The most commonly known vesicant is mustard, which is an oily liquid of light yellow to brown color with an odor of garlic or mustard. Mustard produces no immediate pain or other effects. Thus, persons can be exposed to mustard for several hours without realizing that they are becoming severely exposed. Most blister agents are persistent; mustard, for example, remains dangerous in soil for weeks to years and on other materials for hours to days. Mustard is quickly absorbed into the body via inhalation and skin, causing extreme irritation of the lungs, airways, and eyes. Furthermore, this agent produces effects similar to radiation sickness, leading to cellular death and alteration of the DNA.

Other blister agents include lewisite, which produces moderate to severe pain on contact with the skin or mucous membranes (eyes, nose, mouth, and airways). Lewisite also rapidly kills tissue, resulting in a grayish appearance to the skin.

Blood Agents

The final group of chemical weapons is blood agents, which include cyanide gas. These agents are in the form of liquids that vaporize into a gas shortly after release. Large doses of blood agents such as hydrogen cyanide and cyanogen chloride interfere with the ability of cells to use oxygen. Their most immediate effect is on the ability of the brain to gain sufficient oxygen to function. An exposure to a large amount of hydrogen cyanide leads to sudden loss of consciousness, followed by convulsions. After about 3–5 minutes, the convulsions cease as breathing stops, followed by heart failure within 10 minutes. Blood agents are nonpersistent, but compared to nerve agents, they have a high lethal dose and can be volatile.

Biological Weapons

Biological weapons can use both pathogens (such as bacteria and viruses) and toxins to cause lethal or incapacitating diseases in humans. Since the terrorist attacks on September 11, 2001, a great deal of media attention has focused on the threat posed by biological weapons, with emphasis on agents such as anthrax and smallpox that are ideal for delivery by terrorist networks. The main concern is that such agents, pound for pound, are far more lethal than chemical weapons such as VX. Biological weapons such as pulmonary (inhalation) anthrax could be delivered by a crop duster aircraft as an aerosolized agent; the World Health Organization (WHO) estimates that were such an attack to occur over a city of 500,000 people, approximately 125,000 would be incapacitated and 95,000 would die within 7–10 days.

An even greater challenge is posed by viruses such as smallpox and pneumonic plague, which have a high epidemicity and thus generate very high levels of casualties. Officially, only two WHO stocks of the smallpox virus remain, located at the Centers for Disease Control (CDC) in Atlanta and at Vector Laboratories in Koltsovo, Russia. There is increasing concern, however, that clandestine stockpiles may exist in other states, including North Korea. Prior to the 2003 Iraq conflict, there also were fears that the regime of Saddam Hussein had experimented with camel pox virus, a pathogen closely related to smallpox, possibly as a model for testing the weaponization of the smallpox virus.

With incubation periods ranging from 7 to 17 days, and onset of illness likely after 10 to 12 days, an infected person could spread smallpox unknowingly to people in his or her immediate vicinity through aerobic respiration, or by direct contact and transfer of bodily fluids. In such a scenario, successive waves of infection would then spread out through the population until the "first generation" of victims began to show symptoms. By then, the epidemic would be underway and would be extremely difficult to contain. Smallpox has a 30 percent mortality rate; furthermore, it is physically disfiguring and extremely painful during the later stages of the disease. Smallpox vaccinations last administered in the 1970s are now ineffective, meaning that substantial numbers of people are at risk.

The most likely scenario for a smallpox attack would be the deliberate spread of smallpox in crowded areas such as airports, train and bus terminals, shopping malls, and cinemas. National and global transportation networks would then act as vectors to quickly spread the virus through a population. Such a scenario was considered in a U.S. government terrorism exercise known as Dark Winter that was run at Andrews Air Force Base, Maryland, on June 22–23, 2001. Postulating a smallpox attack on the United States during an international crisis, the participants dealt with a situation in which 3 million people were infected over a period of several months, more than 1 million people died of the disease, and the economic and strategic power of the United States were crippled.

The nature of most biological agents makes them difficult to use militarily. It can be challenging to deliver biological agents on the battlefield, and once delivered and exposed to the outside environment, such agents—particularly viruses—can be killed by sunlight and its associated ultraviolet radiation, or by heat, cold, moisture, and other hazards. There is also the issue of "blow-back," in which a biological agent infects not only enemy troops, but also friendly forces.

Some biological agents could be useful militarily if they could be delivered effectively. For example, Q-fever can be delivered in an aerosol from aircraft or cruise missiles equipped with spray tanks. Once delivered, the agent has an incubation period of up to 26 days. Q-fever incapacitates rather than kills, is very stable as an aerosol, and is very hardy in an external environment. Furthermore, Q-fever is persistent, remaining active for up to 60 days. Those infected will suffer from weeks of fever, headache, chills, weakness, profuse perspiration, respiratory problems, and chest, muscle, and joint pain. As a result of a Q-fever attack, the military effectiveness of an opponent could be substantially reduced. Other "tactical" biological agents include Venezuelan equine encephalitis (VEE) and staphylococcal enterotoxin B (SEB). The latter's effects last just hours, making it of potential use to break through an opponent's defenses or paralyze rear areas at a crucial point in a battle.

Faced with such a prospect, a military force can take protective measures through the use of protective suits and respirators (known as NBC suits; see above), chemical and biological agent detectors, and reconnaissance vehicles to rapidly identify CBW agents should they be released on the battlefield, and by ensuring effective medical responses to CBW casualties. Adequate intelligence and warning, combined with NBC defensive measures, can significantly reduce the effectiveness of an adversary's CBW attacks, though not without a substantial impact on operational battle tempo and overall combat capability. It is the continuing offensive-defensive competition within the field of CBW that is leading to the development of new chemical weapons such as novichok nerve agents and promoting the development of more effective biological weapons designed to undermine defensive measures or deliver greater lethal capability.

Genetically engineered biological agents are a new threat that emerged in the early 1990s. Information gained from Dr. Vladimir Pasechnik (a leading figure in the former Soviet Union's main biological warfare agency, Biopreparat, who defected in October 1989) alluded to Soviet development of genetically enhanced plague and tularemia. The "superplague" has a high epidemicity like smallpox, highlighting the horrifying potential of applying genetic engineering and biotechnology to biological weapons. Through genetic engineering, "legacy agents"—that is, BW agents that will remain viable for longer periods of time—can be enhanced to become more effective, to be resistant to antibiotics, to change characteristics and thus become harder to classify, and to have greater longevity when exposed to the natural environment. Genetically enhanced biological weapons can be made "smart" by being genetically targeted against those with a certain genetic signature (the so-called racial weapon often referred to in the media). Existing nonweaponized viruses such as Ebola and Marburg can be weaponized, and natural toxins, such as snake venom, could be genetically merged through recombinant DNA techniques with pathogens such as the common cold to create devastating new weapons taken directly from nature itself.

It is the potential for genetic engineering to create entirely new and very lethal bioweapons by combining several viruses to produce "chimera agents" that has caught the attention of the popular press in recent years. Former Soviet biological weapons expert Ken Alibek has claimed that Biopreparat created a variety of such agents, including a combination of smallpox and Ebola. Were such a weapon to exist, it could spread rapidly due to the nature of the smallpox component, but, unlike smallpox with its 30 percent mortality, it would exploit the characteristics of Ebola to inflict up to 90 percent fatalities on an infected population, with no vaccine or cure currently available.

The operational utility of superweapons such as an ebola-smallpox chimera or the superplague mentioned above is questionable for nation-state actors. Pasechnik suggested that such weapons would only be used in a total war scenario of mutual annihilation between superpowers, and, as such, they would count as strategic weapons systems. To twenty-first century terrorists, however, such weapons give small groups the ability to lash out at an entire society, or indeed at civilization itself.

On the horizon exists a new class of tactical biological agents known as bioregulators. These are incapacitating agents that are genetically engineered to alter and control the activity of natural bioregulators within the human body—substances that control hormone release, body temperature, sleep, mood, consciousness, and emotions. Delivered as an aerosol, such a weapon would alter bodily functions according to which bioregulators the weapon was designed to influence. Thus, an attacker could deny an adversary force the ability to sleep (thus impairing their functioning), affect their perceptions and mood (perhaps leading to an inability to make decisions effectively or to maintain command of forces), or more drastically, suddenly drive up their body temperatures or undermine their emotional stability.

Chemical and Biological Munitions

The delivery of chemical and biological weapons against unprotected urban areas can occur through irregular means, such as terrorism. If such weapons were be used by a military unit, however, they would need to be delivered by specific munitions for that purpose. These commonly include spray tanks that can be attached to the wing of an aircraft or housed in the warhead of a cruise missile, artillery shells and battlefield rockets equipped with some form of spray dispersal mechanism, and free-fall bombs or cluster munitions designed to break open nonexplosively over a target.

Chemical land mines have also appeared in the arsenals of the Soviet Union and the United States. The U.S. M-23 land mine, for example, contained 10.5 pounds of VX and was capable of acting either in an antipersonnel or antitank role. Longer-range delivery systems for biological weapons might include warheads designed to fit on long-range ballistic missiles. The Soviet Union developed refrigerated warheads for delivery of viruses at intercontinental range with SS-11 ICBMs in the late 1980s, and a dried agent dispersal system for microencapsulated anthrax and plague delivered by SS-18 ICBMs. Such systems have equal application to shorter-range ballistic missiles now appearing in the arsenals of many states, but the complex refrigeration and high-speed dispersal systems are likely to remain technologically challenging for these states. For longer-range attacks, a nuclear weapons capability may be easier to achieve than an effective biological weapons strike capability.

A key development in munitions designed to deliver chemical weapons—specifically nerve agents—was the emergence of binary munitions in the mid 1970s. Rather than handling very dangerous nerve agents (namely sarin and VX) in hollow shells and bombs, the nerve agent was divided into two separate precursor agents that were transported to the battlefield separately. Immediately before firing, the second precursor would be loaded into the weapon (which already contained the first), and once the weapon was in flight, the two precursors would mix, creating the lethal nerve agent. A range of binary munitions was developed, including 8-inch artillery shells and 500-lb. Bigeye free-fall bombs. Binary chemical munitions warheads for the multiple-launch rocket system (MLRS) and the Lance battlefield missile were planned but not produced.

Munitions designed to disperse CBW agents directly onto a target through a free-fall bomb or artillery shell are often described as point source weapons, and delivery systems equipped with a spray tank that allows a CBW agent to be dispersed perpendicular to the wind are described as line source weapons. When working with biological weapons, it is more effective to avoid any sort of explosive dispersal, because the heat and shock generated by an explosive warhead would kill a large proportion of most BW agents. Hence a line source delivery system, such as a spray tank, becomes more effective in delivering such weapons on the battlefield and can allow a wider area to be affected by an attack.

The most sophisticated BW capabilities involve the use of dried agent biological weapons: Rather than using the liquid form of a biological weapon, the agent is converted into dry, powdery particles about 1–10 microns in diameter, which can be more effectively dispersed through the atmosphere. These can also be much more easily inhaled, bypassing many of the human body's defenses, and thus producing a more lethal dose than with liquid agents. Furthermore, unlike liquid agents, dry agents can be stored for longer periods and can be more easily delivered with less sophisticated dispersal mechanisms.

CBW weapons are at the mercy of meteorological conditions, unlike conventional high explosive weapons or nuclear weapons. With chemical weapons, the temperature, wind speed, and potential for precipitation may determine whether or not a chemical attack is successful. The higher the temperatures in the air and on the ground, the quicker a chemical agent will evaporate, making some persistent agents such as VX less effective in dry, hot climates such as the desert. Rainwater can undermine the effectiveness of chemical weapons by diluting chemical agents, dispersing them over a wider area, and reducing the concentration. Obviously, wind speed and direction also play a vital role in determining where a cloud of chemical agent is moving, with higher winds demanding that a greater quantity of agent be employed to achieve a similar effect to smaller amounts on a calm day. With biological weapons, the most favorable time for attacks is at night, and at dawn and sunset. At these times, there is less sunlight to impact the biological agents; also, a layer of cold air above the ground will trap an aerosol cloud close to the ground while further minimizing the effect of sunlight on biological agents.

The challenge posed by chemical and biological weapons is becoming more apparent as new technologies make the weapons themselves more lethal and as the post–September 11 security environment makes more salient the prospect for WMD terrorist attacks. Chemical and biological weapons could become the weapons of choice for states that cannot acquire nuclear weapons but who are challenged by the technologically advanced conventional forces possessed by the United States and its allies. As the "poor man's atom bomb," chemical and biological weapons could be perceived by adversary states as a relatively low-cost force equalizer to U.S. military superiority and as a tool of coercion against neighbors. Genetically enhanced biological weapons in particular open up a Pandora's box of possibilities, and they merit increased consideration as the first truly twenty-first-century weapon of mass destruction.

—Malcolm Davis

See also: Aerosol; Binary Chemical Munitions; Biological Warfare; Blood Agents; Chemical Warfare; Nerve Agents

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CHEMICAL WARFARE

Chemical warfare (CW) is the use of toxic chemicals in battle. The term *gas warfare* is a throwback to World War I–era terms such as *poison gas,* because the earlier battlefield employment of chemicals was indeed in the form of gases. In the modern era, however, chemical compounds used in warfare or terrorism can take the form of liquids, solids, or gases.

As mass casualty weapons, chemicals cause death or injury by their poisonous effects. All CW agents have two main characteristics: they are very poisonous in small quantities (high toxicity), and they have physical attributes that are amenable for use in weapons on the battlefield. CW agents and their precursors are often relatively easy to manufacture and store.

Chemical weapons can be further subdivided into the CW agent—that is, the toxic substance itself in the form of solid, liquid, or gas—and the weapon used to deliver that agent (bomb, artillery shell, etc.). Thus, a delivery system such as an artillery shell becomes a chemical weapon when filled with CW agent.

Chemical terrorism refers to smaller-scale attacks upon civilians or governmental institutions, and, like CW, chemical terrorism is a rare occurrence. In 1994–1995, however, a political/religious organization called the Aum Shinrikyo (Sect of the Supreme

Truth) in Japan used sarin nerve agent, an extremely lethal chemical agent, in two major attacks that killed at least nineteen people. (The organic chemist involved, Tsuchiya Masami, received the death penalty, and a similar sentence was likely to be given for the cult's guru, Shoko Asahara.) Sarin is a standard military CW agent that was stockpiled by both the United States and the former Soviet Union during the Cold War. Tens of thousands of tons of CW agents are still in storage, mostly in Russia and the United States, but these stockpiles are scheduled for destruction under the terms of the 1992 Chemical Weapons Convention (CWC).

Although the basic idea behind CW is simple, in practice, a chemical attack against a modern military force is an extraordinarily challenging undertaking. One might think that, in this modern industrial era, there must be hundreds of toxic chemicals that could be effectively used as means of warfare. In actuality, though, few are effective enough to be used in a battlefield setting. During World War I, for instance, traditional poisons such as hydrogen cyanide (HCN) failed to produce mass casualties. Through deliberate scientific research and a good deal of trial and error, several basic threat chemicals have been identified that could pose a significant battlefield or terrorist threat: nerve agents (e.g., sarin), blister agents (e.g., mustard, lewisite), blood agents (e.g., HCN), choking agents such as phosgene and perfluoroisobutylene (PFIB), and psychoincapacitants (e.g., BZ or 3-quinuclidinyl benzilate).

History of Chemical Warfare

Even in prehistoric times, people may have employed irritating smoke generated by burning branches and leaves to ward off predators or to draw prey into killing zones. Some of the earliest written accounts of using poison as a form of warfare go back to as early as the fourth millennium B.C.E. in India. These involved snake venom being applied to the tips of arrows, as well as other toxins being used to cause discomfort and confusion among the enemy. Chinese writings going back at least three millennia, including the *Gunpowder Epic* (*Wujing Zongyao*) and other military classics, mention the use of toxic smokes (including arsenic) against enemy sappers (engineers who conduct mining to destroy fortifications, as well as to conduct de-mining operations). Various forms of incendiaries such as napalm have traditionally been placed under the rubric of chemical weaponry, although few would now consider this classification valid.

Producing toxic fumes, especially in confined areas such as tunnels, is one classic technique that could be accurately termed chemical warfare. Long ago, ancient armies burned sulfur and pitch to force the enemy to surrender, or simply to harass enemy forces. In the fourth century B.C.E., the famous Greek military strategist Aeneias Tacticus noted the utility of using smoke to deter the enemy from digging mines under one's fortifications. Written at about the same time, the Chinese historical record *Mo Zi* contains prescriptions for how to combine firewood, grass, reeds, and other combustibles to defend against enemy miners.

The mining technique was also employed in Roman times (approximately 190 B.C.E.). One Roman commander, Marcus Fulvius, attacked a Greek city by tunneling under the city's fortified walls. The Greeks (Ambraciots), however, deployed large pots of burning coal and feathers that produced, in addition to rather toxic fumes, a horrific stench. In this way, the Greeks were able to drive back the Roman miners. The Chinese *Gunpowder Epic* also mentions using arsenic, a very toxic metal, in making smoke bombs, and this technique may have been used in battle by 1000 C.E.

With the advent of chemistry as a scientific discipline and of modern industrial technologies, mass production and use of highly toxic compounds became an obvious way to inflict significant casualties on an opponent's forces. The chemical sciences developed and flourished in the Islamic world during medieval times. It was not until the eighteenth century, however, that the Industrial Revolution could bring economies of scale in the mass production of chemicals. In the nineteenth century, the famous chemist Michael Faraday, who pioneered the technique of liquefying gases, was asked by the British government how chemicals could be used as weapons against Russia during the Crimean War. Although his expertise told him that such an idea was feasible, he also found the notion repellent, and refused to have anything to do with it. It also was about this time that remarkable advances were being made in the field of organic chemistry, with its many applications being used in rapidly growing industries such as textiles, pharmaceuticals, and explosives.

World War I occurred at a time when Germany was leading this chemical phase of the Industrial Revolution. Although Europe and, to a lesser extent, the United States were well equipped with technical and industrial expertise to make great profits from chemicals, Germany had established an effective government-business relationship in its society that further enhanced its share of the chemical market.

The use of chemicals in World War I left an abhorrent image of helpless soldiers in makeshift gas masks struggling for breath, or ranks of soldiers blinded by mustard agent attacks. In reality, though, chemical weapons caused relatively few deaths and injuries compared to conventional weapons; when the war was over, chemical weapons had caused less than 4 percent of all casualties. Furthermore, the death rate from chemical injuries in World War I ran about 3 percent. For the United States, approximately 2 percent of the gas casualties died, compared to the 8 percent death rate from gunshot wounds during World War I. One could ask why CW has gained such a fulsome reputation when its use did not fundamentally affect the course of World War I, or, arguably, of any war since then. Richard Price (1997) offers the following explanation in his book, *The Chemical Weapons Taboo:* "Chemical weapons, which had been temporarily singled out during The Hague's grand deliberations on international arbitration and the law of war, became an effective scapegoat for the disillusionment with the promise of technology that followed World War I" (p. 165).

Classification of CW agents

CW agents are grouped within categories based on their effects on the human body. Traditionally these are listed as choking, blister, blood (systemic), and nerve agents. Other CW agent types exist—including riot control agents (RCAs), incapacitants, and compounds that destroy vegetation (herbicides)—but these are not usually included in the traditional categories. Not all of the ways in which CW agents poison their victims have been satisfactorily explained, although two main mechanisms are often at work in the toxicology (study of poisonous compounds) of CW agents: reactions with molecules in the body that directly or indirectly cause tissue damage, pain, and other effects; and the binding and blocking of larger macromolecules called enzymes that are vital for normal bodily functions. Enzymes are protein molecule-based structures that catalyze (i.e., speed up and reduce) the activation energy required for chemical reactions. Some CW agents have a tendency to come into contact with and bind or otherwise impair important enzyme functions.

Choking Agents

Choking agents or choking gases are those that irritate and injure the lungs, causing a buildup of fluid (edema) in the lungs and preventing the uptake of oxygen. Chlorine and phosgene, for example, are classic choking gases that were used during World War I.

The first major chemical assault that produced significant numbers of casualties was done by the German military in 1915 with chlorine gas (Cl_2), released from cylinders into a cloud that drifted with the wind toward the opposing military forces. In this case, the Germans utilized about 500 tons of chlorine gas made available from stocks provided by the German chemical (dye) industry. The chlorine was loaded into canisters under pressure, and as the chlorine was released from a liquid state into a gas, it mixed with moisture in the air and made clouds of chlorine-water mists.

When chlorine is inhaled, a combination of hydrochloric acid and hypochlorous acid is formed. In large enough concentrations, these caustic and irritating compounds damage lung tissue. Damage to the lung tissue causes blood plasma to infiltrate through the injured sites in the lung and to fill up the spaces left by the damage. The result of inhalation injury by this choking gas can be so severe that frothy, blood-tinged fluid builds up in the lung and is coughed up following exposure. Even with assisted breathing, the victim chokes on his or her own fluid (thus the term *choking agent*). In old military manuals, this was also referred to as *dry land drowning.* The classic 1918 poem by Wilfred Owen, *Dulce et Decorum Est*—written about a gas attack during World War I—specifically refers to the "choking" and "drowning" of such victims (quoted in Sidell, 1997, p. vi).

Phosgene, a commonly used chemical for civilian industrial processes, is a compound that can affect the body's enzymes and tissues. This choking gas, also used in World War I (1915), may not have had the overall impact of mustard or other agents, but did cause more deaths in proportion to overall injury during World War I (approximately 80 percent). At the molecular level, phosgene gas is breathed in the lungs, and can react with vulnerable chemical constituents in enzymes and tissues. Furthermore, phosgene reacts with water in the body to produce hydrochloric acid. In combination with its reactions with key chemicals in the lung tissues, phosgene makes injury worse by producing acidic by-products. The overall consequences of inhaling phosgene are similar to those of chlorine, but phosgene is many times more toxic.

Blood Agents

Blood agents include the important compound cyanide, or more precisely hydrocyanic acid (HCN). Cyanide blocks the utilization of oxygen in mammalian systems. Because cyanide has been a classic poison throughout history, its effects have long been noted. And as cyanide seemed to early observers to affect the entire body, and therefore was assumed to somehow affect the blood, it was described as a blood agent. One could say that HCN is an asphyxiant in a sense, stopping oxygen uptake in the body. Cyanide directly reacts with an enzyme complex, cytochrome oxidase (the suffix *–ase* indicates an enzyme), that moves oxygen and electrons along in a chain reaction. If enough hydrocyanic acid is introduced to the human system, cyanide will stop this chain of energy and oxygen transfer, resulting in death. Some have likened this poisoning event to shutting off a water hose at the source.

Despite HCN's high toxicity, it actually is not as toxic as many other compounds. And although HCN is in liquid form at room temperature, it evaporates so quickly that creating lethal concentrations in the open field is quite difficult. Due to its high volatility, or tendency to form a vapor, HCN is quickly dissipated by the wind and by other atmospheric conditions. French, German, American, Japanese, and Russian militaries in the past several decades, for example, all tried to develop HCN as a battlefield weapon without much success. Subsequent developments included cyanogen chloride, a more stable version of cyanide, and was stockpiled in small quantities by the major powers. Although this improved version appeared later in World War I, this development did not make much of an overall impact, as the weapon still suffered from many of the same drawbacks as HCN.

Blister Agents

Blister agents include the mustard and lewisite compounds that were developed in the years 1917–1918. Although mustard did not cause as many deaths in proportion to total casualties, the blistering and blinding effects of mustard were extremely potent on the battlefield. Mustard has been used in considerable quantity in at least three major wars: World War I, the Italian campaigns in Ethiopia (1935–1936), and the Iran-Iraq War of 1980–1988. In the latter conflict, an estimated 45,000 Iranians were injured, 5,000 of these fatally, by Iraqi use of CW agents. Most of these casualties were probably the result of mustard. Sulfur mustard is a relatively cheap and simple compound to produce, making it a likely CW agent. On the other hand, mustard is not nearly as lethal as are the nerve agents, and it is therefore unlikely to be a chemical sought by terrorists.

Mustard, at least until the development of the more highly toxic nerve agents, was considered the king of CW agents. Mustard is a rather thick or viscous liquid at room temperature, and it is less volatile than water. (Lightweight motor oil is a close comparative example to the physical properties of mustard.) For use against concentrations of soldiers in the field, mustard is most effective when delivered in the form of an aerosol (a suspension of very tiny droplets or particles that remain suspended in air for a significant period of time—fog is a rough equivalent to an aerosol). Mustard can be made into an aerosol by simply using an explosive charge in a shell or bomb that disperses the agent after a quick, violent blast of energy. The tiny droplets of mustard form a dense cloud of agent that presents two major threats: exposure via inhalation, and contact with the skin. Larger droplets that immediately fall to the ground are also a hazard: Shoes, garments, and equipment can become contaminated with the agent, and personnel can be exposed to these sources of mustard.

How mustard causes the blistering, irritation, and severe tissue destruction it causes is not exactly known. In 1985, however, Bruno Papirmeister and his colleagues at the U.S. Army Medical Research Institute of Chemical Defense hypothesized some very likely mechanisms of mustard poisoning in the human system. First, mustard (unlike water) can be absorbed through the outer skin layer. Second, the mustard molecule undergoes a change in its structure, becomes very reactive, and can bind (alkylate, or join on a molecular level) with key components in the structure of DNA. The nucleic acid guanine is particularly susceptible to reactions with the mustard molecule. This can cause breaks and errors in cellular DNA formation and repair, resulting in cellular death. (A similar process can take place in cases of ionizing forms of radiation.) Third, mustard can target other key components by chemically attacking the sulfhydryl (SH) groups commonly found in proteins and key enzymes. This process leads to the autolysis, or breakdown, of dead cells and their structures, reducing proteins and related compounds into smaller chemical components. Enzymes called proteases are released that break down cell walls and other cell parts that maintain the structural integrity of tissue. As the enzymes break down the cells into their basic components, including a substantial proportion of water, this results in pus-filled blisters. Depending upon the amount of exposure, blisters form about an hour or more following contact with mustard.

The eyes are especially sensitive to mustard, and exposure to this agent causes so much eye pain and itching that affected individuals must keep their eyelids shut. Permanent blindness caused by mustard-induced injury can occur, although most victims recover well enough to keep at least partial vision. Other areas of the body that are very vulnerable to mustard poisoning include the more delicate skin layers (epidermis) under the arms and in the groin. There can be severe irritation in the armpits, where the motion of the arms can aggravate the discomfort, and irritation in the groin area can make ordinary tasks such as walking unbearable.

The discomfort and tissue injury caused by blistering can leave permanent scars and requires a considerable amount of time to heal, but long-term side effects from single exposures to mustard are generally not life-threatening. Cancers and birth defects in children born of individuals exposed to mustard are possible, but they are most likely to occur in those who have routinely been in the presence of mustard, such as workers involved in its production over a period of months or years. Death from mustard can occur from contact with about two grams of this agent, such as the inhaling of a significant quantity of vapor. Mustard causes tissue damage in the upper respiratory tract, resulting in blockage of airways. Larger exposures can also involve the lower respiratory tree and the lungs. As in other cases of lethal CW agent exposures, asphyxiation is the direct cause of death.

Lewisite is another blister agent, and although it was produced in the United States in 1918, it was never used in World War I. Lewisite has some of the blistering effects of mustard, but it acts more quickly and produces immediate irritating effects. Lewisite has not been seen in many cases of actual warfare, and cases of human exposure are few. It is named after its inventor, W. Lee Lewis, who developed the compound as a "dew of death" in 1917. By the time large quantities were produced for use in battles, however, the war in Europe was nearly over. Because the molecule of lewisite is built around one atom of arsenic, it is classified as an arsenical-type agent. Lewisite is an extremely potent, irritating substance affecting skin and eyes, and it is also a significant inhalation and contact hazard.

Because lewisite freezes at a very low temperature, much lower than that of sulfur mustard, militaries such as the former Soviet Red Army often mixed lewisite with mustard for use in very cold weather. Not only would this mixture bring the freezing point down considerably below zero degrees centigrade, but the combined effects of both agents would also present a very dangerous contaminant for the battlefield. Lewisite poisons to a great extent by its ability to react with sulfhydryl (SH) groups in tissues, key enzymes, and amino acids such as glutathione. Lewisite produces redness, blistering, and irritation in human skin, and it also behaves as a systemic poison, causing further injury to various organs of the body. Although more toxic than mustard, lewisite is still far less deadly than the nerve agents. Therefore, although its military effectiveness is undoubtedly high, it is unclear what role (if any) lewisite may play in chemical terrorism.

Nerve Agents

Nerve agents were synthesized in the 1930s by both German and Allied (U.K.) scientists during World War II, although only Germany produced actual wartime stocks of these very toxic substances. In the later stages of the war (1944–1945), German military scientists produced large quantities of tabun nerve agent (apparently code-named after a nonsensical word). More commonly known nerve agents developed for use in CW are sarin and VX.

All nerve agents share the same toxic principle: Disruption of the biochemistry vital for normal function of the nervous system. These compounds have been used in the Iran-Iraq War (1980–1988) and in two major terrorist attacks in Japan during the mid-1990s.

Nerve agents were first created from investigative research into new insecticides based on organophosphorus molecules (those possessing carbon and phosphorus in their structures). In 1937, the German chemist Gerhard Schräder and his team synthesized a potential organophosphorus insecticide but found that it was highly toxic to mammals. A drop of the substance, later called tabun, fell on the laboratory table. Schräder and an assistant soon began to show signs of poisoning, including the classic symptom of pinpoint pupils (miosis). This compound was given to the German wartime government as a possible chemical weapon. During the 1940s, British scientists, notably Bernard Saunders, also experimented with nerve agent compounds, as well as with cyanide and other compounds with fluorine.

Nerve agents like tabun share in common a so-called leaving group, a chemical constituent of the molecule that leaves to reveal a reactive site. This site can react (phosphorylate) with susceptible groups in enzymes. The primary enzyme targeted by the nerve agent molecule is acetylcholinesterase (AChE). Normally, AChE performs the life-sustaining function of taking the nerve signal transmitter (neurotransmitter) acetylcholine and splitting it into acetic acid and choline, both of which are recycled by yet another enzyme to form acetylcholine again later when needed. AChE splits acetylcholine at a rate of hundreds of molecules per second. This enzyme not only provides for muscle fiber flexing, but also for fluid excretion and normal breathing, among many other bodily functions. If this enzyme is blocked or inhibited, levels of acetylcholine will continue to rise. This sets off a series of events that leads to death by respiratory arrest, either due to exhaustion or, more likely, asphyxiation by accumulating mucous and saliva in the airways. Thus, despite their very different mechanisms, nerve agents can also produce "dry land drowning" as does chlorine in the classic sense of "gas warfare."

Nerve agents are extremely toxic even when compared to other CW agents. All nerve agents are liquid at room temperature, but different types of nerve agents vary in their volatility. As with mustard, high concentrations of nerve agent are best delivered through the use of aerosols. VX nerve agent does not evaporate very quickly, much less so than mustard, but sarin, a nerve agent used on the Tokyo subway by terrorists in 1995, volatilizes at about the same rate as water. Therefore, although militaries would use nerve agents as aerosols to maximize their effectiveness in the field, terrorists may employ simpler, even crude methods of delivery.

Other CW Agents

Incapacitants

A number of compounds have been developed to harass rather than kill the enemy, thereby making opposing soldiers a less effective fighting force. A nonsubtle form of this is the use of riot control agents (RCAs), commonly referred to as tear gas. Usually, these compounds are not very toxic (certainly less poisonous than other CW agents), and they are meant to cause discomfort to the enemy. Chloracetophenon (CN) is a liquid agent developed during World War I, and although it was produced too late for use in that conflict, it has been used since then. In large concentrations, CN is quite toxic, but in smaller doses it usually only causes irritation to the nose, throat, and especially to the eyes (thus the term *tear gas*). Mace is a commercial product that uses CN for civilian, personal protection.

Most often used in modern times is CS, a crystalline substance that is usually delivered as a powdery aerosol, but also can be used in the form of a thermal vapor. Although CS causes much more immediate and severe discomfort to the eyes, nasal passages, and upper respiratory tract than CN, CS is less poisonous than CN in terms of general toxicity. Therefore, governments and their police agencies sometimes use CS against civilians to quell riots or prison disturbances. Using CS to encourage unruly mobs to disperse is considered to be more humane than using clubs or bullets to restore the peace.

BZ is a very potent incapacitant that was once a part of the U.S. chemical arsenal. This drug actually belongs to the same group of compounds as atropine, although BZ is significantly more potent, causing severe (although temporary) mental disturbances when administered. Persons intoxicated with BZ will have distorted perceptions of visual and other sensory realities, as well as altered states of situational awareness. The distortion of mental behavior may last for several hours to a few days, but it usually goes away without lingering effects. Its unpredictability as a weapon was a major reason the U.S. military decided to get rid of its BZ stocks in the late 1980s and early 1990s.

Herbicides

No longer part of U.S. military strategy (except for use in specific tasks such as clearing vegetation around airfields), herbicides such as weed killers were used by the British army in Malaysia in the 1950s and to a much greater extent in Vietnam by the U.S. Air Force. The main targets of herbicides are plants and trees that may give cover to the enemy, as well as crops grown by the opposition for food. Although herbicides only attack plants, by assaulting enemy food supplies one could indirectly consider the use of herbicides as a form of CW. One of the most effective herbicides, 2,4-D (2,4-dichlorophenoxyacetic acid) formed the significant portion of Agent Orange, the mixture (2,4-D and 2,4,5-T) used in Vietnam by the U.S. military.

As a so-called growth regulator, 2,4-D kills plants by inducing changes in their growth cycle, and it is nontoxic to mammals. 2,4-D is still commonly used today and can be found in local nurseries and hardware stores. Many U.S. Vietnam War veterans claimed injury due to a contaminant in Agent Orange used during the war, dioxin (2,3,7,8 tetrachlorodibenzo-*para*-dioxin). Although dioxin was present in Agent Orange as a by-product of its production, no scientific study has yet proven a causal link between dioxin and disease in humans.

Treatment of CW Agent Casualties

Some CW agents and their injuries are treatable, but others lack effective remedies besides supportive care. Mustard poisoning, for example, is still not effectively treatable once the agent has absorbed through the skin surface or respiratory tissues. Advances in supportive therapy, however, including the use of antibiotics to keep bacterial infections in check, have increased the likelihood of CW survival. Lewisite has a standard treatment that attempts to take out arsenic through a process called chelation. Still, the so-called British Anti-Lewisite (BAL) treatment has yet to be proven fully effective as an antidote for lewisite poisoning. Given a timely medical response, antidotes for cyanide poisoning are effective. One method involves using a drug (amyl nitrite) to induce a chemical change in hemoglobin, the oxygen-carrying component in the blood. This change in the structure of hemoglobin, now called methemoglobin, attracts the cyanide molecule to the hemoglobin much faster than it would otherwise bind to cytochrome oxidase. This forms a harmless molecule (cyanomethemoglobin) complex that the body can safely process, keeping free cyanide from interfering with the cytochrome oxidase oxygen transport system.

Nerve agents are the most toxic and lethal CW agents thus far devised for use as weapons. Fortunately, there exist effective treatments for nerve agent intoxication. The first line of defense against nerve agent poisoning is a drug called atropine. This compound has been used for centuries in various ways, one of these being to cause the dilation of the pupils in the eyes. At one time, it was very fashionable in Europe for women to have dilated pupils, and extracts such as atropine from the belladonna group of plants were used for this purpose. Today, atropine is used to widen pupils during eye examinations. This drug and others like it are still referred to as the belladonna group of compounds, from the Italian for beautiful (bella) lady (donna).

To a certain extent, the effects of atropine counterbalance those of nerve agents. Nerve agents block or inhibit the function of acetylcholinesterase (AChE) enzyme, resulting in an increase in acetylcholine molecules. This acetylcholine continues to stimulate receptors in the nervous system, causing exhaustion in the muscles used for breathing, changes in heart rhythm, and secretions in the throat that can asphyxiate the victim. Atropine, on the other hand, is a so-called anticholinergic compound that partially blocks receptors in the nervous system, protecting them from excessive levels of acetylcholine stimulation. Although atropine does little for the involuntary twitching in skeletal muscles caused by nerve agents, it does help to dry up secretions and restore some normalcy to the rest of the system. Longer-term treatment for nerve agent exposure may also include chemical compounds called oximes. These help restore the normal activity of AChE by releasing the enzyme (via dephosphorylation) from its bonds to the nerve agent. Oxime treatment in conjunction with atropine increases the chances of survival for those exposed to nerve agents.

Additionally, pretreatment for nerve agent exposure can be effective in protecting against intoxication. In some instances, militaries may gather intelligence indicating that an enemy plans to use nerve agents in battle. Soldiers then can be prepared by taking one of a family of drugs called carbamates. Carbamates, such as pyridostigmine bromide, actually behave somewhat like nerve agents: Carbamates can bind themselves with AChE, but they do so only temporarily, forming reversible complexes. In the event of nerve agent exposure, lethal nerve agent molecules now have to compete with the carbamates already in the system. Because carbamates only loosely attach themselves to AChE, the enzyme is eventually released back to normal function while the nerve agent molecules are gradually cleared (detoxified) from the system. Carbamates are especially recommended if nerve agents like soman may be used against one's military forces. Soman, more than other nerve agents, has a tendency to bind permanently and block AChE, making the protection of available enzyme by the use of carbamates even more desirable.

CW Agents and Terrorism

Terrorism can be generally described as an act of political violence aimed at a government and its citizenry. Most terrorist acts—car bombs, hijacking of aircraft, and assassinations—still employ age-old techniques and devices including explosives, bullets, and sharp instruments. Also, most terrorist attacks are not intended to cause mass casualties, but rather to create destructive events that may cause death and injury in spectacular fashion. Often, terrorists have wider political goals in mind, such as the formation of a separate country (separatist movements), removal of what is perceived as an occupying power, or criminal activities. The act of violence itself, rather than trying to directly attack an enemy, is an attempt to make a larger impact by frightening, bullying, or causing a government and its people to feel insecure.

There are examples of terrorists using chemical weapons, but these are actually rather few in proportion to the many acts committed during the past century or so. The numbers of deaths and injuries from chemical weapons in terrorism have also been relatively low, especially when one considers the potential impact that large amounts of chemical agents could actually create. It is unclear, furthermore, why terrorists would use chemical weapons if other more proven methods—explosives, bullets, or knives—have achieved their goals.

Chemicals, nevertheless, may represent a notable and fearsome weapon in the arsenal of the terrorist, with an impact that goes beyond just numbers of casualties. CW agents can act as silent and unseen killers, further adding to the mystique sought by terrorists.

—Eric A. Croddy

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CHEMICAL WEAPONS CONVENTION (CWC)

The 1993 Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on their Destruction (known more simply as the Chemical Weapons Convention, or CWC) entered into force on April 29, 1997 as the first verifiable treaty to ban an entire category of weapons of mass destruction. As of January 11, 2003, 148 nations had formally ratified participation in the Convention by their governments, or simply acceded, and 20 had neither signed nor ratified it. Among states of particular interest, India, Iran, Pakistan, Sudan, and states that made up the former Yugoslavia (Bosnia and Herzegovina, Croatia, Serbia and Montenegro) are parties to the treaty. Egypt, Iraq, Libya, North Korea, and Syria are among the nonsignatory states. Israel has signed but not ratified the treaty. (The reasons for Israel's nonratification and the refusal of some Arab states to sign the CWC are generally related to broader political considerations, such as the political linkage between chemical and nuclear weapons. Some states in the Middle East have indicated that they will not ratify the CWC until Israel becomes party to the Nuclear Nonproliferation Treaty.)

Definition of a Chemical Weapon

The CWC defines a chemical weapon as essentially consisting of one or more of three elements: (1) toxic chemicals and their precursors in a type and quantity not consistent with the object and purpose of the treaty, (2) munitions and devices that are specifically designed to cause death or harm through the use of such chemicals, and (3) any equipment specifically designed for use directly in connection with the employment of munitions and devices specified in (2). A key element in the CWC's definition of a chemical weapon is the fact that it bans the production, development, stockpiling, and use of *all* toxic chemicals and their precursors except when used for peaceful purposes. This so-called general purpose criterion is incorporated in the definition of a chemical weapon. The reasoning behind it is to ensure that chemicals not listed in the CWC's Annex on Chemicals are still prohibited as a means of warfare, while also taking into account any relevant future technological and scientific developments that could be utilized in chemical weaponry. The definition was structured so as to assist in the verification of destruction of storage tanks, unfilled munitions, and binary chemical weapons components.

Background

The main international legal instrument dealing with chemical weapons prior to the CWC's entry into force was the Geneva Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous, or Other Gases, and of Bacteriological Methods of Warfare (the Geneva Protocol, 1925). The Geneva Protocol did not, however, prevent the stockpiling of chemical weapons. Furthermore, many of the major powers attached conditions to their instruments of ratification: for example, provisions that a state would not consider itself bound by treaty obligations if first attacked with chemical weapons, or if it were involved in a military conflict with nonsignatory states or with military coalitions that included one or more nonsignatory states.

Other agreements regarding chemical weapons include the International Declaration Concerning the Laws and Customs of War, signed at the Brussels Conference of 1874; the conventions signed at the First International Peace Conference (The Hague, 1899) and the Second International Peace Conference (The Hague, 1907); the Treaty of Peace with Germany (also known as the Treaty of Versailles, signed on June 28, 1919); and the Treaty of Washington of 1922, Relating to the Use of Submarines and Noxious Gases in Warfare (signed in Washington, D.C., on February 6, 1922).

Groundwork in CWC negotiations began in 1968 within the framework of the UN Eighteen-Nation Committee on Disarmament (the present-day Conference on Disarmament). Discussions on a treaty banning biological and toxin weapons were conducted separately from those concerning chemical weapons and resulted in the 1972 Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Bacteriological and Toxin Weapons and on their Destruction (the Biological and Toxin Weapons Convention, or BTWC).

The CWC was negotiated within the context of the Cold War. The United States and the Soviet Union negotiated a bilateral agreement on chemical weapons in parallel with the multilateral negotiations on chemical disarmament. The bilateral negotiations resulted in the Agreement on Destruction and Nonproduction of Chemical Weapons and on Measures to Facilitate the Multilateral Convention on Banning Chemical Weapons, signed on June 1, 1990. Although the latter agreement was never fully implemented, the CWC's verification of compliance procedures are largely based on that bilateral agreement. Provisions for providing emergency assistance to member states that are the victims of chemical weapons or are threatened with chemical weapons, as well as technological assistance and cooperation provisions, were also included toward the end of the 1990 bilateral chemical treaty negotiations.

The OPCW

The Organization for the Prohibition of Chemical Weapons (OPCW), based in The Hague, Netherlands, is mandated to verify the destruction of chemical weapons—including old and abandoned chemical weapons—as well as to verify the destruction or conversion of former chemical weapon production facilities. It also has the tasks of confirming that national defense establishments and national chemical industries are not engaged in prohibited activities, of monitoring the trade in certain chemicals that could be useful to a chemical weapons program, of providing assistance and protection to states that are threatened by or are the victims of chemical weapons, and of promoting economic and technological development in the field of chemistry among treaty parties. The OPCW has also provided parties with technical expertise and advice on chemical weapon-related matters such as the planning and implementation of weapon destruction programs.

Parties are required to provide annual declarations on defense-related activities and on the production, consumption, and transfer of certain chemicals. Chemical weapon-related facilities (including chemical weapon storage and destruction facilities), and facilities working with small quantities of chemical warfare agents for research, medical, pharmaceutical, or protective purposes are then subject to international inspections. Segments of the chemical industry are also subject to visits by inspectors. These result in a final inspection report to help provide assurance among parties that they are all in compliance.

Schedule 1, 2, and 3 Chemicals

Although any use of chemicals as a means of warfare is prohibited under the CWC, certain chemicals known to have been used as CW agents are listed in schedules, while others are included due to their potential use as CW agent precursors. In the Schedule 1 category, CW agents that have typically been developed for warfare—and have no other practical purpose—are listed, including the nerve agents (e.g., sarin) and mustard agent. States may produce these in small quantities only for peaceful defensive purposes, and there are strict reporting guidelines in these cases. Schedule 2 chemicals include toxic chemicals that could be utilized as a means of warfare, such as amiton (nerve agent), or other chemicals that could be used to produce Schedule 1 chemicals. Countries may produce Schedule 2 chemicals but only for peaceful purposes, and their trade is restricted to CWC parties. Finally, Schedule 3 includes classic World War I–era gases such as chlorine. These chemicals are often used in commercial products, and their strict regulation would be too burdensome for the chemical industry worldwide. These can be produced in large quantities so long as they are for peaceful uses.

The chemical industry is subject to declaration and inspection requirements in two ways. One is on the basis of chemicals contained in the CWC's Annex on Chemicals and certain other, unlisted discrete organic chemicals that may contain the elements phosphorus, sulfur, or fluorine (DOC/PSFs). These elements are found in nerve and mustard agents, thus their inclusion for verification purposes. The second is through the general-purpose criterion mentioned above.

Implementation of the CWC

The CWC is implemented by the OPCW. The OPCW consists of the Conference of the States Parties (CSP), the Executive Council (EC), and the Technical Secretariat. The CSP is the highest decision-making body. It meets in regular session once per year. The EC, which is composed of forty-one members representing five geographical groupings, meets in regular session three to four times per year. It develops and considers draft recommendations, decisions, and guidelines for the approval of the CSP, including the annual draft program and budget. It also plays a key role in implementing the CWC's provisions on consultations, cooperation, and fact-finding, up to and including challenge inspections—that is, states must comply with on-the-spot, "any time, anywhere" inspections if and when approved by the OPCW—and investigations of alleged chemical weapon use. The Secretariat, which currently has about 500 employees (200 of them inspectors), is responsible for carrying out the treaty's verification measures and providing administrative and technical support to the CSP, EC, and various subsidiary organs, such at the Scientific Advisory Board (SAB) and the Commission on the Settlement of Disputes Relating to Confidentiality. The OPCW's budget for 2003 was approximately 68.6 million euros, funding provided on a sliding scale by each State Party.

As of December 2002, the OPCW had conducted a total of 1,276 inspections at 5,237 declared sites and facilities (both military and civilian). Four countries had declared chemical weapon stockpiles totaling some 70,000 agent metric tons: the United States, Russia, India, and South Korea. The CWC mandates these stockpiles' destruction within 10 to 15 years after the CWC's entry into force; large-scale destruction operations are underway in all four countries. By 2003, sixty-three chemical weapon production facilities in eleven party nations had been declared, and nine parties had declared their possession of old chemical weapons. (Old chemical weapons are those produced before 1925, or chemical weapons produced between 1925 and 1946 that have been determined to be unusable.)

The countries that have declared chemical weapon production facilities—defined as any facility that produced chemical weapons at any time since January 1, 1946—are Bosnia and Herzegovina, China, France, India, Iran, Japan, Russia, South Korea, the United Kingdom, the United States, and Yugoslavia. Three parties have declared having abandoned chemical weapons (i.e., leaving chemical weapons abandoned after January 1, 1925 on the territory of another state without the consent of the latter). The largest quantity of abandoned chemical weapons was those that were left in China by Japan at the end of the Second World War, totaling at least one million munitions. The CWC does not require that chemical weapons dumped (such as in the ocean) before January 1, 1985, be declared. Nor does it require that chemical weapons buried on a party's territory before January 1, 1977, (and that remain buried) be declared. As of 2003, no sea-dumped chemical weapons had been declared, nor had there been any challenge inspections or investigations of alleged use or production of chemical weapons.

Inspections have generally proceeded smoothly from an operational point of view, and no party has been formally accused of noncompliance. However, parties, including the United States, have requested and received clarification regarding other parties' declarations through the CWC's provisions for consultations, cooperation, and fact-finding. Currently, most outstanding verification-related issues relate to cost, scope, and intrusiveness, especially with regard to the chemical industry.

Although the United States has questioned Iran's compliance with the CWC, it has done so outside the framework of the OPCW. Iran did not declare a chemical weapon stockpile, but rather a past production capability. (For its part, U.S. statements have not referred to an existing chemical weapon stockpile in Iran.) More general discussions are currently taking place in the OPCW on how much detail parties should give on past programs and capabilities. There is a desire to increase openness among parties in this area, but there is also concern that some types of detail could be misused politically.

International cooperation and assistance programs are a major attraction for becoming a party to the CWC. Under the OPCW's Associate Program, for example, small groups of scientists and engineers from developing countries undergo a short course of study at a selected university in a participating state. Following the completion of studies, they are placed at modern chemical industry facilities for practical training designed to assist participants in better familiarizing themselves with modern industrial practices. The participants are asked to work on a specific problem, usually related to improving a chemical process. All participants, including the companies involved, have generally been pleased with the results.

Current and Future Challenges

Two of the main areas of focus since the CWC's entry into force have been the destruction of chemical weapon stockpiles and achieving universality in terms of state participation. With some notable exceptions, the treaty is now essentially universal, that is, nearly all important states are participating in the CWC. As chemical weapon stockpiles are gradually eliminated, the OPCW's focus will shift toward other areas, including technological assistance and cooperation, monitoring of chemical transfers, and taking measures to help ensure that the treaty regime keeps up to date with continuing scientific and technological changes. Parties also need to remain aware of possible toxic chemicals not on the CWC's list that may be used for prohibited purposes and of new developments in chemical industry manufacturing processes that may facilitate hiding of prohibited activities. The latter is particularly suited to smaller, more versatile facilities that produce relatively small quantities of fine chemicals to order in "batch mode." Such facilities may use lines of automated microreactors capable of producing chemical agents or toxins that could be used in weapons. In addition, the distinction between biological and chemical processes is increasingly blurred. The SAB has played an important role in these and other areas.

There is a continuing need for the OPCW to acquire periodically updated measurement and analytical equipment, for the Secretariat to continue to carry out practice challenge inspections and investigations of alleged use in cooperation with member states. The OPCW also needs to take steps to ensure that inspectors are familiar with the latest scientific and technological developments and that relevant institutional memory is maintained. The OPCW also should devote greater attention to ensuring that it is in a position to provide assistance and protection to member states who are threatened with, or have been the victims of, an attack using chemical weapons.

The CWC regime is a relatively robust regime as compared with other multilateral arms control and disarmament treaties. CWC implementation has resulted in significantly greater transparency of past and present chemical weapon-related programs and activities among parties. Much of this transparency has not been extended to the broader public because parties—with some exceptions—are responsible for indicating how much of their information may be disseminated outside the OPCW. There is little reason to suppose, however, that the CWC cannot continue to play a necessary and useful role in the future, as long as parties remain politically and financially committed to the treaty.

—John Hart

See also: Australia Group; Geneva Protocol; Hague Convention; Precursors

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CHLAMYDIA PSITTACI (PSITTACOSIS)

Psittacosis, or ornithosis, also called parrot fever, is a worldwide disease primarily of psittacines (parrots, parakeets, etc.) caused by the bacterium *Chlamydia psittaci.* The genus *Chlamydia* is a group of bacteria responsible for various diseases. Transmission to humans from infected birds usually occurs via direct contact or inhalation of dried droppings and secretions. Birds that otherwise appear healthy can shed *C. psittaci* bacteria intermittently, especially when stressed, and even brief exposure can lead to infection. Human-to-human transmission is very rare.

According to the U.S. Centers for Disease Control and Prevention (CDC), psittacosis is a category B bioterror threat, a less serious but potential biological weapon agent (*see* Centers for Disease Control and Prevention). This classification is due to the pathogen's moderately easy dissemination, moderate morbidity, low mortality, and the requirement for specific enhancements in diagnostic capacity and disease surveillance. Although cited as a potential adversary agent (presumably aerosolized), it is not known to have been used. The Soviet Union, the United States, and Canada have performed research on psittacosis in the past, mostly during the World War II era and the early years of the Cold War (1950–1960s).

Psittacosis was first recognized in 1892 in Paris. That year, it was responsible for the death of sixteen out of forty-eight infected people. Between 1985 and 1995, a total of 1,132 cases (undoubtedly underestimated due to the difficulty of diagnosis) of psittacosis were reported worldwide, mostly resulting from exposure to pet birds. Since 1996, fewer than fifty annual confirmed cases have been reported in the United States.

The severity of the human form of the disease ranges from nonapparent to abrupt, systemic illness (1–4 weeks, but sometimes years, following exposure). Symptoms include fever, headache, chills, nausea, lethargy, and a nonproductive cough, potentially followed by severe pneumonia. The elderly are particularly susceptible to the disease. No vaccine is available, but effective antibiotics (mainly tetracycline) have reduced the fatality rate from 20 percent to less than 1 percent.

The severity of avian psittacosis (also called avian chlamydiosis) depends on the species of bird, strain virulence, and stress factors. Signs include lethargy, weight loss, ruffled feathers, nasal discharge, diarrhea, and excretion of green urates. In the absence of treatment, the disease can lead to emaciation, dehydration, and death (usually due to an unchecked infection of the heart). *C. psittaci* has been isolated from more than 100 bird species. Various strains can infect other animals, including sheep, goats, and cattle, causing reproductive infection and abortion; and felines, leading to rhinitis and conjunctivitis.

Due to the transmissibility of *C. psittaci,* its resistance to environmental stress (*C. psittaci* can remain infectious for several months, and the bacteria are stable in seawater for up to 24 hours), and its lack of overt symptoms in some birds, this organism could potentially be used in a covert attack on agriculture. An attack using *C. psittaci* could target the poultry industry using a form of aerosol delivery, causing widespread bird-to-bird infection. This would likely lead to wholesale culling of poultry from infected areas in order to control the disease, and large financial losses. Infection of poultry farmers, veterinarians, and poultry handlers could also increase, with an initially moderate to low mortality rate, with infection and mortality decreasing over time with the eventual identification of the causative agent and with the resulting appropriate antibiotic treatment. The diagnosis of psittacosis, however, can be difficult.

Although *Chlamydia* is an obligate intracellular pathogen (i.e., requiring host cell nutrients for reproduction), making it relatively difficult to produce and weaponize, a number of countries have the capability to produce and disseminate this agent. The infective dose, however, is unknown. Targeting humans directly with aerosol delivery is also possible.

—Beverley Rider

See also: Aerosol; Agroterrorism

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CHLORINE GAS

As a lung irritant, chlorine (Cl_2) is the quintessential agent once found in true "gas" warfare. The World War I chlorine gas attack by the Germans at Ypres, Belgium, on April 22, 1915, was considered a signal event that heralded the era of modern chemical weaponry. Clouds of chlorine gas broke the salient at Ypres for a short time, but German infantry reserves were not sufficient to exploit the breakthrough offensive. Although not the first use of chemical weapons in World War I, this attack was unprecedented in terms of scope and overall effectiveness.

In 1823, the British chemist Michael Faraday (1791–1867) first liquefied chlorine gas. Since then, chlorine has been one of the most widely used chemicals for industry. Mass production of chlorine is carried out by electrolysis, the use of electricity to separate the elements of salt (sodium chloride), collecting the chlorine gas as it is separated from the brine, while also producing sodium for use in making another useful chemical (caustic soda). In World War I, the amount of chlorine brought to the war

Chlorine is still widely used and hazardous—as in this accidental release of the gas in New York in 1944. (Bettmann/Corbis)

front in April 1915 (approximately 170 tons) represented a sizeable portion of Germany's available industrial stock. In 1945, some 150,000 tons of chlorine were produced in the United States. By 2001, U.S. consumption of chlorine was estimated at 14 million tons.

When liquefied under pressure, chlorine gas can be released into the atmosphere by simply allowing it to escape via a pressure valve or a puncture of its container. The density of chlorine gas keeps it low to the ground. This feature made it an attractive weapon for use against dug-in trenches in World War I. And yet, not long after the infamous German use of chlorine (and Allied responses in kind a few months later), this chemical became obsolete due to its relatively low toxicity and the use of protective masks on the battlefield.

Chlorine gas is only effective as a weapon through the inhalation route. The toxicity of chlorine gas is primarily due to the production of acidic by-products upon contact with the body's moist airways (especially in the lungs), resulting in the release of hydrochloric and hypochlorous acid. Chlorine gas can produce an immediate irritating sensation in the nasal passages, with tightening in the upper airways followed by a very severe cough. Depending on the amount of exposure, damage in the lungs leads to swelling of tissues (pulmonary edema), with blood leaking from the injured alveoli. Very severe cases of chlorine inhalation lead to frothy, blood-tinged sputum. Thus the old term *dry-land drowning:* as their own body fluids enter the lung air spaces, no further gas exchange can take place, and victims choke to death. Apart from assisted breathing and supportive care, there is little medical intervention that is effective in the event of significant levels of chlorine inhalation. Survivors, however, usually make full recoveries.

In January 1915, the German chemist Fritz Haber saw that the use of high explosives was not sufficient to change the momentum on the battlefield. At this stage in World War I, the great armies were nearly at a standstill in trenches that served as nearly impenetrable redoubts stretching for miles. After experiments showed that gas could be brought to bear on the enemy, Haber won approval to do so from General von Falkenhayn, who diverted chlorine gas cylinders from industry. A total of 5,730 cylinders were assembled along a 6-kilometer front, and they were distributed with about one cylinder per meter.

Germany had not undertaken this venture without considering international law. The Hague Conference of 1899 forbade the use of poisons in warfare, and Germany was a signatory to it. However, a German account of the events by Dr. Rudolph Hanslian (1940) suggests that before the use of chlorine at Ypres, the following considerations were made: "Haber laid his reflections and his plan before Falkenhayn and the latter agreed. No fundamental scruples based on international law existed in the view of Falkenhayn, nor was the toxicity of chlorine as great as that of the materials bromethylacetate and chloracetone already introduced by the French" (Hanslian, p. 12).

These references made to French use of chemicals may have been with regard to irritating compounds such as ethylbromoacetate (which had also been employed as a riot control agent in Paris as early as 1912). Sporadic use of these chemicals had also found its way to the battlefields of World War I, often delivered in the form of French rifle grenades. Thus, at least according to the version of events mentioned above, Germany saw the use of chlorine as a measured response—in degree if not in kind—to the previous use of chemicals by French grenadiers. Following the war, some apologists for Germany also noted that using static gas cylinders was technically not the use of "poisonous projectiles" as described in the Hague document. Haber could not find a ready supply of adequate artillery shells to deliver chemicals, and at that time chlorine cylinders were the only practical means of gas dissemination.

It appears certain that Allied claims of 5,000 soldiers having perished and 15,000 having been injured along the front at Ypres must be an exaggeration for propaganda purposes. It is now the considered opinion of most analysts that no more than 800 Algerian, Canadian, and French soldiers died during the April 22, 1915, gas attack. Further postwar commentary, including that by Russian military experts, suggested that a combination of chlorine and phosgene would have been much more effective at Ypres. The German military was certainly aware of this, but it claimed that it did not use that mix out of consideration of international law.

Concerns about toxic industrial chemicals in warfare were also raised during the conflict in the Balkans, particularly in the mid- and late 1990s. With this in mind, a U.S. Army field manual (*FM 3-06.11*, 2002) has drawn the following assessment, using data compiled by Croatian engineers: "The models indicated that with a normal load of 16 cubic meters per railcar, a lethal concentration of chlorine could extend up to 5 kilometers downwind and that serious adverse health effects could occur as far as 12 kilometers downwind" (*FM-3*, section FM-7, b). These estimates roughly parallel the World War I experience at Ypres in 1915. Just as Germany confiscated chlorine from its domestic chemical industry for use by its military, chlorine poses a modern risk primarily due to its possible diversion from the commercial market by terrorists.

—Eric A. Croddy

See also: Choking Agents; World War I; Ypres

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CHLOROPICRIN (PS, TRICHLORONITROMETHANE)

Chloropicrin was first synthesized in 1848 by the English chemist John Stenhouse, who derived this product from a reaction with picric acid and calcium hypochlorite. Chloropicrin originally got its name from the chemicals used in its preparation, that is, chlorine (in the form of bleach) and picric acid. Variations of this method were later used for large-scale production of chloropicrin.

During World War I, Russia was the first major belligerent to use chloropicrin (also called trichloronitromethane) as a chemical weapon; this was in August 1916. Soon the British were also using chloropicrin in a 30:70 ratio with chlorine in a mixture called Yellow Star gas. Chloropicrin was prepared for delivery in artillery shells, bombs, and land mines. Some German chemical munitions in World War II also contained chloropicrin, combined with obscurant smoke preparations such as titanium chloride and tin chloride. It is unknown whether these were used in the European theater of combat. In the older and now defunct U.S. chemical inventory, munitions included a combination of chloroacetophenon (CN) and chloropicrin (PS in NATO terminology) together in a chloroform solvent (20:40:40). This chemical munition was coded CNS. Other suggested uses for chloropicrin (in the form of CNS) involved its dissemination from aircraft with other CW agents such as mustard. Mixtures of CNS and ethyldichlorarsine (ED) were at one time considered to be potentially effective for use in aerial spraying and bombardments, and Prentiss (1937) recommends spraying these as a means of "harassing" enemy troop concentrations. Following the development of more toxic chemical compounds such as mustard and the nerve agents, however, as well as the development of improved protective mask canisters, chloropicrin after World War II was largely considered obsolete as a war gas.

Military chemists in World War I found chloropicrin particularly advantageous for its ability to remain liquid over wide temperature ranges: it boils at about 112° C., and freezes at -64° C. An oily, colorless liquid, chloropicrin has traditionally been considered an extremely effective lacrimator, irritating the eyes and the mucous membranes in the respiratory tract. Furthermore, chloropicrin causes damage to the pulmonary tract and was therefore classified as a lung irritant following its initial use in World War I. An estimated concentration of 0.2 milligrams per liter is sufficient to incapacitate soldiers, and 2 milligrams per liter over 10 minutes of exposure is likely to be lethal. As in the case of other lung irritants such as phosgene, treatment of severe cases of chloropicrin inhalation is generally limited to mechanical ventilation and other supportive care, with no specific antidote currently available.

Although chloropicrin is not quite as deadly as phosgene, it penetrated most of the early gas masks used in the initial stages of gas warfare in World War I. Until activated charcoal was introduced for protective canisters, chloropicrin often forced the enemy to take their masks off, leaving them vulnerable to simultaneous attack by other lethal agents. Thereafter, chloropicrin was often used in quality control for testing gas masks, their filter canisters being rated by the number of hours they could defend against chloropicrin exposure.

In the early twentieth century, chloropicrin was commonly used by itself to kill vermin such as rodents in Russia and the rest of the former Soviet Union. Thus, the Red Army had large stockpiles to draw upon for use as a CW agent. Later, in World War II, for example, large numbers of voles contributed to an outbreak of tularemia on the Stalingrad front. (Former Soviet BW scientist Ken Alibek has suggested that the Soviets deliberately used tularemia bacteria as a biological weapon during the siege of Stalingrad. This claim is difficult to substantiate.) Soviet hygienists were dispatched to combat the rodents with arsenic compounds (possibly arsine gas or solid baits) and chloropicrin. Red Army chemical defense schools also reportedly used chloropicrin to simulate contaminated ground for training. Combinations of chloropicrin with mustard agent and phosgene were also used for chemical weapons in the former Soviet chemical weapons stockpile.

Chloropicrin is an example of a CW agent that has commercial as well as offensive (dual-use) applications, and today it is used in large quantities as a fungicidal soil fumigant for high-value crops (flowers and strawberries, for example) and as a warning odor adjunct in pesticides—as a safety precaution, the pungent aroma will signal that the area is under chemical fumigation. Pest control companies, for example, are required by law in the United States to use about 1–3 ounces of chloropicrin (depending on the size of the structure) when fumigating structures with fumigants such as sulfuryl fluoride (VIKANE). In recent years, concerns over the environmental impact from the use of methyl bromide (purportedly a contributor to ozone depletion) as a common soil fumigant have led to the adoption of chloropicrin for the purpose instead. Commercially, chloropicrin can be found in a number of trademarked fumigants, including Acquinite, Chlor-O-Pic, Larvacide, Pic-Chlor, and Tri-Clor, as well as combination formulations such as BromO-Gas and Terr-O-Gas.

Because it is so widely available in the agrichemical industries, chloropicrin has the potential for diversion for use in chemical warfare or terrorism. But again, the toxicity of chloropicrin is by no means exceptional, and there are many other widely available compounds that could be similarly used in weapons of mass destruction.

—Eric A. Croddy

See also: Dual-Use; World War I

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CHOKING AGENTS (ASPHYXIANTS)

Choking agents or asphyxiants—also technically referred to as lung irritants—are the chemical compounds that gave rise to literal gas warfare in the modern era. Asphyxiating agents used in chemical warfare injure the respiratory pathways, most importantly the delicate alveoli in the lungs where critical gas exchange takes place. Serious lung injury brings about pulmonary edema and asphyxia. As the lung spaces fill with the body's own fluid, the victim can no longer respire enough oxygen, and he or she dies. In other types of toxic inhalation, casualties may result from being overwhelmed by a number of chemical substances such as by-products of fires, explosives, or the use of riot control agents (tear gas) in enclosed spaces. For example, it is possible that many of the eighty victims who died in Waco, Texas, at the 1993 Branch Davidian complex siege expired from suffocation and not as a result of the fire at the complex. Both the fire and resultant deaths were likely caused in part by large quantities of CS tear gas delivered in methyl chloride solvent.

Some household products have the potential to become lethal choking gases. Most notable among these are the extremely toxic chloramines that are created from mixing bleach (sodium hypochlorite) with ammonia. The resultant gas can be more toxic than bleach or ammonia by themselves, as chloramines can dissociate into both compounds upon contacting the moist upper and lower airways.

Choking agents were the first CW agents produced in large quantities, and they were used extensively during World War I. Gases that are heavier than air, such as chlorine and phosgene, filled depressions and sank into revetments, a characteristic well suited to the trench warfare that typified combat at that time. In World War I, the choking gases initially made a significant impact, but they contributed proportionately less to overall casualties as the war progressed. For example, American Expeditionary Forces arriving late in the war (1917) were much more affected by the use of mustard agent, a vesicant, than by the combined use of the choking gases by the enemy, for which they were better prepared.

Chlorine

Because these are for the most part highly volatile liquids or gases at room temperature, the classic lung irritants disperse rapidly in the atmosphere. This characteristic, combined with their relatively low toxicity (when compared to the nerve agents, for example), makes their use as a weapon of mass destruction less appealing to state militaries or to terrorists. These compounds are also less of a threat for the twenty-first century battlefield because of changes in battlefield tactics and advances in protective masks. Terrorists, however, could acquire choking gases in some form, perhaps diverted from the chemical industry in bulk form, and could manage to kill or injure large numbers of unprotected citizens.

Although the use of chlorine as a weapon is now generally considered obsolete, occasionally it does reappear in modern conflicts. According to an unconfirmed report, the Liberation Tigers of Tamil Eelam (LTTE) used chlorine in a 1990 attack against Sri Lankan forces. Little more information is known about the incident, and this attack did not result in serious casualties. A report in 1997 claimed that Muslims in the Bosnian city of Tuzla, the site of a significant industrial chemical facility, produced 120-millimeter chlorine-filled mortar rounds in anticipation of conflict with Serbian-led forces. It is not known whether any of these shells were used.

Among the first recorded uses of choking gas was a 431 C.E. campaign by Spartans, who burned pitch and sulfur to generate sulfur dioxide smoke. In one siege, the use of this toxic gas helped persuade the Athenians to surrender. The advent of modern chemical warfare essentially began in April 1915, with the successful use of chlorine (Cl_2), a choking gas, on the World War I battlefield of Ypres, Belgium. This chlorine, diverted from the German dye industry, was brought in canisters to the front. When the wind speed and direction were right (i.e., blowing toward the enemy), the German line opened the valves on the cylinders, releasing the gas. At least 800 Allied soldiers died in this attack. Other lung irritants, as well as phosgene, diphosgene, and chloropicrin, were introduced during World War I, these chemicals being delivered in shells such as the Livens projector, a type of mortar that fired a large gas cylinder.

For the conditions of World War I, chlorine satisfied some essential requirements for a chemical weapon. Although it was found to be sufficiently toxic for its purpose (although not as toxic as many other CW agents), chlorine was inexpensive to produce, especially for industrialized nations. Even before the mass production of chlorine got underway during World War I, chlorine sold for about a nickel a pound. As a poisonous gas, chlorine upon exposure almost immediately irritates the nasal passages, constricts the chest, and, in larger amounts (approximately 2.5 milligrams per quart of air), causes death by asphyxiation. Although it was initially effective in World War I, chlorine's distinctive bleach smell—and eerie, greenish color—quickly made its presence known, and the advance warning allowed for defensive preparations and tactical retreat.

Chlorine gas reacts quickly with the moisture in the body's airways and lungs, forming a mixture of hydrochloric and hypochlorous acids (thus the bleach odor one finds in hypochlorite). Although the body can absorb a certain amount of acid without complaint or injury, large doses create injury in the lung tissues. Hypochlorous acid reacts with a number of protein and fat constituents in the lungs, most severely in the alveoli. This damage leads to pulmonary edema (swelling and fluid buildup), with coughing exacerbating the injury and bringing up blood-tinged sputum. When Lieutenant Wilfred Owen wrote his poem about chemical warfare (CW) in World War I, "*Dulce et Decorum Est,*" he referred to the physiological effects of chlorine: "As under a green sea, I saw him drowning. In all of my dreams, before my helpless sight, He plunges at me, guttering, choking, drowning" (quoted in Sidell, 1997, p. vi). Owen was killed in France on November 4, 1918.

Chlorine's high reactivity with a number of substances made possible ad hoc protective measures. In World War I, soldiers quickly found that makeshift masks soaked in certain chemicals (sodium thiosulfate, glycerine, and alkali) offered good protection against chlorine. Six months after first being used in World War I, chlorine by itself no longer made a significant impact on the battlefield. But chlorine remained as an essential part of phosgene mixtures later on, and it was a critical part of the production process for more toxic and highly lethal compounds to follow.

Phosgene

Phosgene was first used as a weapon by Germany in December 1915. Compared to chlorine, phosgene gas is a much more insidious and deadly chemical agent. Even at toxic levels, phosgene (carbonyl dichloride) has little distinguishing odor and usually kills its victims only after a considerable delay (up to 24 hours). In one instance during World War I, a soldier was given the responsibility of checking phosgene canisters. A day later, the same soldier died from phosgene exposure, unaware that one of these canisters had formed a small leak. Although it may not have contributed to a large percentage of casualties overall, phosgene was alone responsible for some 80 percent of those killed by chemicals in World War I. In World War II, the U.S. Air Force had in its arsenal 500-pound phosgene aerial munitions, although these and other chemical weapons were never used in that conflict.

The common perception once was that phosgene exposure led to the formation of acid in the lungs, which then destroyed tissue. However, this explanation is not adequate to explain how phosgene, even in very small concentrations, can do so much irreparable damage to the lungs. (The toxicity of phosgene, for example, is 800 times that of inhaled hydrochloric acid.) Phosgene reacts with a number of biochemical components in the body, especially enzymes and the processes required to maintain proper surface tension in the lung alveoli. An examination of World War I gas warfare victims found that, in addition to its effects on the lungs, phosgene also causes specific injury to the central nervous system.

Phosgene has been used in at least one instance by terrorists. In this case, a Japanese reporter who had written stories about Aum Shinrikyo was singled out for assassination by the cult. Aum henchmen dispersed phosgene through the mail slot in the journalist's apartment. After a brief hospitalization, the reporter made a full recovery. Aum Shinrikyo also had a substantial presence in Russia during the early 1990s; during this time, Russian security personnel also found phosgene in the possession of Aum Shinrikyo in an apartment in Moscow.

As with chlorine gas exposure, treatment for phosgene injuries is mostly limited to supportive care. World War I chemical masks utilized hexamethamine tetramine (HMT) to defend against phosgene. In the late 1930s, some research suggested that this compound was useful for protecting against phosgene-related injury, but the data are still not clear. It was also considered impractical to use this chemical prophylactically on the battlefield.

Diphosgene

Diphosgene essentially relies upon the toxicological properties of phosgene, but diphosgene also released chloroform. As a solvent, chloroform may have been utilized as a "mask breaker." Germany used diphosgene for the first time in 1916, and the French responded later in kind.

Chloropicrin

Chloropicrin was first used by Russia in World War I. It was probably derived from the pesticide industry. Chloropicrin is an immediately irritating substance, and it is still used to create a warning odor for the fumigation of large structures. California law, for example, requires about 1 ounce of chloropicrin during the "tenting" of houses for insecticide treatment. Concerns over the environmental effects of methyl bromide for soil fumigation have led to considering the use of chloropicrin instead. (For more on this chemical, see the separate entry Cholopicrin.)

Perfluoroisobutylene

Another highly toxic gas, perfluoroisobutylene (PFIB), known as the agent in "polymer fume fever," is a potential military or terrorist chemical threat. Because it is many times more toxic than phosgene, PFIB was made a Schedule 2 toxic chemical in the Chemical Weapons Convention (1993). The inclusion in Schedule 2 was suggested due to its potential use as a weapon, and the fact that it can be commonly found as a byproduct or intermediate chemical in some industries. PFIB can be generated during processes for the manufacture of fluorinated polymers (e.g., Teflon), or in heating these polymers to high temperature (over 500° F.). Military-specified materials used in tarpaulins and ropes contain Teflon; following an incendiary attack, for example, fires could generate toxic levels of PFIB.

Nitrogen Oxides

Finally, although not likely to be related to a deliberate use of toxic gas on the battlefield, nitrogen-containing explosives generate significant quantities of NO_x (as in nitrogen oxides, NO_2, N_2O_4, etc.). These by-products can be the source of toxic inhalation injury in battlefield settings, and casualties may present in many ways similar to those exposed to lung irritants such as chlorine or phosgene. The Chinese People's Liberation Army still makes the claim that the United States used chemical weapons during the Korean War (1950–1953). It is likely, however, that many of the battlefield casualties among the Chinese People's Volunteers during the Korean War died from asphyxiation due to off-gases from exploding munitions. Many Chinese soldiers were essentially holed up in earthen fortifications that allowed toxic gases like NO_x, carbon dioxide, and carbon monoxide to accumulate. Soviet military advisors who were requested by the Chinese government to investigate allegations of chemical warfare in the Korean War came to the same conclusion.

Industrial Accidents

The hazards of choking agents present themselves most often in industrial settings. A tragic example of this was the Bhopal disaster of 1984, which involved the massive release of methyl isocyanate in a densely populated area of India. Due to what probably was insider sabotage, thousands of pounds of methyl isocyanate—an extremely toxic lung irritant—killed at least 3,000 people, injuring thousands more (*see* Bhopal, India: Union Carbide Accident). Because potentially harmful chemicals such as chlorine and anhydrous ammonia (NH_3) are used throughout the industrialized world, their bulk storage could present targets for terrorist attacks. Chlorine is ubiquitous, not only as a chemical reactant for commercial processes but also for water treatment. Ammonia is widely used in rural areas in concentrated form as fertilizer, and it is also a cost-effective coolant for public utilities.

For these industrial chemicals and the hazards they could pose, meteorological conditions play a critical role. In the case of Bhopal, the release of methyl isocyanate occurred during an inversion, the optimal situation for high concentrations of a gas to linger for a long period of time. Alternatively, chemical releases are mitigated during conditions of unstable air (lapse) and of high winds that quickly dissipate the concentration.

—*Eric A. Croddy*

See also: Bhopal, India: Union Carbide Accident; Chemical Warfare; Chlorine Gas; Perfluoroisobutylene (PFIB); Phosgene Gas (Carbonyl Chloride); World War I

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CHOLERA (*VIBRIO CHOLERAE)*

Vibrio cholerae is a gram-negative bacterium that causes cholera, a diarrheal disease, in humans. Infection can lead to a massive, secretory diarrhea that results in a life-threatening loss of fluids in the infected patient. Transmission is typically through an oral route, usually as the result of drinking water contaminated with *V. cholerae.* The organism grows in the small intestine and secretes an enterotoxin (choleragen) that disrupts the osmotic homeostasis of the intestine, resulting in the secretion of water into the intestinal cavity. Cholera could potentially be employable as a biological warfare agent by contaminating food or posttreatment water supplies. Another species, *Vibrio parahaemolyticus,* also causes severe diarrhea in humans following the consumption of infected raw seafood (especially in Japan). This bacterium also could have a potential role in sabotage, such as poisoning food and water.

In 1848, the British physician John Snow, a trained anesthesiologist, set out to find the source of an especially severe outbreak of cholera in London. In his classic work *On the Mode of Transmission of Cholera* (1849), Snow concluded that contaminated water was the source of the widespread disease. Using techniques recognizable today in modern epidemiology, Snow also sought to understand the origins of another serious cholera outbreak in 1854, tracing victims and water sources to a single water pump. Known for having obtained a pure culture of *Bacillus anthracis* (anthrax), Robert Koch discovered the causative agent for cholera in 1883.

Vibrio cholerae is capable of causing epidemic and pandemic disease. Cholera is particularly devastating in areas with marginal hygiene or inadequate medical support, particularly in refugee camps and among impoverished populations with inadequate water treatment infrastructure. The German army is alleged to have used cholera in Italy in World War I, although evidence for this is largely anecdotal. Cholera was one of several biological agents developed by the Japanese in the infamous Unit 731 offensive biological warfare laboratory. Cholera was reportedly disseminated against Chinese villagers in 1940, along with typhus and plague, in support of Japan's invasion of China.

Following the Japanese attack on Pearl Harbor, the threat of water-borne agents (including cholera) was among the key concerns behind a biological threat reduction plan for U.S. bases in the Pacific theater. Germany's biological warfare program was considerably less advanced than their work with chemical agents, but they had experimented with, and perhaps had produced in volume, cholera as an antipersonnel agent that could be used against logistical units in support of large military forces. Soviet scientists purportedly developed strains of *Vibrio cholerae* that exhibited enhanced virulence and antibiotic resistance as part of the USSR's biowarfare research initiatives. Claims of the use of cholera by U.S. forces against North Korea were levied by

China and Russia in 1952. It is possible that North Korean prisoners were exposed to cholera and plague by Chinese field advisors to the North Korean army and were then flaunted as "victims" of the U.S. biological attacks.

The world is presently experiencing the seventh pandemic (worldwide outbreak) of cholera. The current pandemic is thought to have started in Indonesia in 1961 and has spread through the Middle East, Asia, Africa, and South America. Of concern to public health officials is the emergence of a second biotype of *V. cholerae* in Bangladesh and its subsequent spread throughout Southeast Asia. In modern industrialized countries, cholera is less of a threat due to residual chlorine in the water supply that keeps bacterial populations low in number. In Peru, an especially severe outbreak of cholera (biotype El Tor) was exacerbated in 1991 when Peru lowered the amount of residual chlorine in its water system, and the disease spread to sixteen other Latin American countries.

Medical Properties

Cholera is generally acquired by oral ingestion of water or food containing *V. cholerae,* typically as the result of fecal contamination from patients or from asymptomatic carriers of the bacteria. The organism colonizes the lining of the small intestine and secretes choleragen, a toxic protein. Infection causes a spectrum of disease severity, and many individuals do not exhibit the profound diarrheal illness often associated with cholera; however, asymptomatic individuals can pass *V. cholerae* in their feces and can serve as reservoirs of the disease agent. The biochemical properties of the intestinal epithelial cells are altered by choleragen such that these cells lose their ability to regulate water loss from the body. The resulting pathology contributes to massive, watery diarrhea, with patients reported to have lost between 10 and 20 liters of fluid during the course of the infection. Mortality may exceed 50 percent in the absence of supportive therapy. Infection with *V. cholerae* is treatable with readily available antibiotics; fatality rates can be reduced to less than 2 percent with effective intervention. Multiple biotypes (or serogroups) of *V. cholera* exist. Most important to human disease are the O1 (synonym El Tor) and O139 (synonym Bengal). Both are recognized as potential agents of epidemic and pandemic disease. Rehydration therapy and supplemental electrolyte solutions significantly reduce the morbidity and mortality of cholera infection.

Cholera continues to be considered a potential biological threat, although it is a low-risk threat agent for domestic terrorism in most industrialized nations. Cholera vaccines are no longer available to the general population in the United States, principally as a result of their rather limited and short-duration protection. Oral vaccines are available outside the United States that afford better protection and may convey protective immunity following a single-dose administration. Public health authorities do not recommend vaccination for travelers, given the lack of an efficacious vaccine and the negligible risk of exposure. The duration and extent of the seventh cholera pandemic is unknown, but it is not considered to be a significant health risk to most travelers.

The lack of serious risk of cholera, even in the context of domestic bioterrorism, has reduced the level of federally funded cholera research in the United States. It is quite likely that a considerable level of concern would be needed before substantive reinvestment in cholera research or vaccine development would occur. Developments continue, however, on rapid detection kits and sensors for cholera toxin.

—J. Russ Forney

See also: Biological Warfare; Japan and WMD

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CONOTOXIN

Conus, or cone shells (also called marine snails), are predacious animals whose venom is used to immobilize their prey. They are found resting in shallow-water sand or under coral or rocks in the daytime. At night they become active predators. *Conus aulicus, C. geographus, C. gloria-maris, C. marmoreus, C. omaria, C. striatus, C. textile,* and *C. tulipa* are capable of inflicting human fatalities.

To acquire food, a conus extends a radular tooth (a harpoonlike apparatus) to inject venom, paralyzing the prey. The conus venom contains a variety of polypeptide toxins, composed of amino acids bonded in a chain. These various toxins affect different aspects of the nervous system. There are also types of conotoxin that induce sleep (sleeper peptides) and muscle damage (myotoxin). Conotoxins and other types found in marine animals have been suggested as possible biological warfare agents. However, these are also fragile proteins, and their toxicities are not generally high enough to make effective weapons.

—*Anthony Tu*

See also: Bioterrorism; Toxins (Natural)

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CRIMEAN-CONGO HEMORRHAGIC FEVER

Crimean-Congo hemorrhagic fever (CCHF) is a viral disease that occurs sporadically in western and central Asia, eastern Europe, and Africa. It was first observed in workers clearing agricultural lands in Soviet Crimea during World War II. Natural transmission of the virus is often through tick bites or contact with infected livestock. The resulting illness often shows hemorrhage and shock. Convalescence can be prolonged, and death occurs in 10–30 percent of patients who come down with the disease. Infection of animals exposed to CCHF is often inapparent, even while the virus circulates in the bloodstream (viremia). The body fluids of slaughtered animals are thus a frequent cause of unexpected disease. Accidental inhalation of virus-contaminated fluids during care of human patients has been a recurring cause of hospital-centered CCHF outbreaks. For this and other reasons, CCHF virus is one of several candidates for aerosol dissemination in biowarfare.

In 1969, Jordi Casals showed a link between Crimean viral illnesses reported in the former Soviet Union in 1944 and a disease of African patients in the Congo that occurred in 1956. Despite such a wide geographic separation, viruses from these ecologically diverse regions nonetheless generated antibodies that were indistinguishable from each other. Many species of forest and domestic animals can acquire CCHF infections, and small wild animals or livestock serve as reservoirs of the virus. This in turn supports an infected population of blood-feeding ticks to serve as vectors. Virus spread among ticks can also be sustained by infection of the eggs in female ticks and transmission to offspring.

CCHF is caused by a midsize virus (0.1 micron) belonging to the family of bunyaviruses (genus *Nairovirus*). Its genes form helical strands of RNA and are protected by a protein coat and fatty envelope, facilitating virus entry into host cells by utilizing receptors on the surface. In the first round of virus multiplication, RNA of the host cell primes expression of the virus genome, the essential genetic information for replication. The virus then becomes self-replicating and produces proteins that are essential to its maturation and release from the cells. After contamination of broken skin or a tick bite, the virus multiplies in local tissues. The onset of clinical disease is rapid. In addition to common flulike symptoms and joint soreness, patients may complain of abdominal pain or sore throat. Within 24–96 hours, the virus spreads through the bloodstream to multiply in many of the body's organs. The liver, especially, is a major site of virus multiplication. This disrupts production of blood clotting factors and contributes to bleeding manifestations.

Signs of hemorrhagic fever include bleeding from the gums or nose, seepage of blood under the skin (ecchymoses), and blood in the urine or stools. Hemorrhagic complications often indicate life-threatening disease; they reflect a combination of liver failure, virus growth in the lining of blood vessels, and exhaustion of clotting factors. CCHF is fatal in up to 30 percent of cases, with most deaths occurring within 1–2 weeks. The virus can persist for up to 10 days in the blood or other tissues and can be detected by tissue culture, brain inoculation of suckling mice (for culture growth of virus), or more recent techniques utilizing polymerase chain reaction (PCR, which can multiply small amounts of genetic material for easier detection). In the past, diagnosis usually depended upon laboratory detection of protective antibodies that appear 7–10 days after infection. In fatal cases, though, there may be a poor antibody response, so virus culture or PCR detection is essential for diagnosis. Patients with CCHF often become weak and lethargic, and convalescence can require 3–6 weeks.

Vaccination with heat-inactivated CCHF virus has been tested on a small scale in eastern Europe, but the efficacy and safety of the vaccine are uncertain. Protection through the use of clothing and insecticides by livestock handlers are basic measures that can limit the spread of CCHF. Hospitalized patients suspected of having the disease must be strictly isolated to prevent spread to medical workers. Physicians should be wary of mistaking the abdominal signs of a virus infection for a surgical emergency. Treatment of CCHF usually is symptom-oriented. Replacement of fluid loss or clotting factors may be necessary. In severe cases, the antiviral drug ribavirin or immune plasma from recovered patients may help to control infection.

The potential for criminal use of CCHF as an aerosol obviously exists. Exposed military or civilian populations could be severely debilitated for many weeks. To date, however, no known artificial outbreaks of this disease have occurred. A type of virus sharing similarities to CCHF, Rift Valley Fever (RVF), has been tested for use in biowarfare by the U.S. Army, although the results are classified. This agent was not reported to be a major consideration in the Soviet bioweapons program.

—*Phil Grimley*

See also: Hemorrhagic Fevers; Marburg Virus; Rift Valley Fever

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CROP DUSTERS (AERIAL APPLICATORS)

The threat from aircraft dispensing a lethal substance has been a concern since at least the beginning of military aviation. During World War I, the extremely toxic arsenical compound lewisite was synthesized and developed in 1917, intended for delivery by aircraft over enemy concentrations. (This was partly what earned Lewisite its moniker, dew of death.) Shortly before the outbreak of World War II, an erudite commentator from the 1930s described the threat from "aerial chemical warfare," and suggested that sulfur mustard could be poured from modified barrels kept in the fuselage of a aircraft.

The large-scale spraying of pesticides from aerial applicators was also a pre-World War II idea. In the 1930s, the U.S. Army Air Corps refined techniques that would prove useful for the application of DDT. As a consequence of dealing with disease-carrying vectors and unwanted vegetation during modern times, the techniques and engineering were already in place for the herbicidal campaigns conducted by the U.S. military during the Vietnam War. These were conducted largely from the air, dispensing enormous quantities of herbicides such as Agent Orange over South Vietnam and Laos. Although herbicides and insecticides like DDT are only toxic to the targeted pests in question, it is not a great leap to convert aircraft to deliver highly potent chemical warfare (CW) agents. By using a highly toxic substance such as VX, an aerial application system could be utilized to spray lethal droplets of nerve agents over densely populated areas, with catastrophic results. Furthermore, with the myriad applications of aerial chemical spraying used every day around the world, one can easily imagine the possible role of aerial applicators in bioterrorism.

From the perspective of delivering chemical warfare or biological warfare (BW) agents, crop dusters used in the modern civilian agricultural industry could be diverted into weapons of mass destruction (WMD) platforms. These include rotary and fixed-wing aircraft that are capable of disseminating particulates and aerosols, usually for the purpose of crop protection, mosquito abatement, and other civilian uses. For example, in the 1990s, while attempting to account for and disarm Iraq's various WMD programs, United Nations inspectors had suspicions about Iraq's work with aerial spray mechanisms. Although Iraqi officials claimed that these were solely for use in agriculture, U.N. Special Commission (UNSCOM) inspectors in Iraq found that these so-called Zubaidy devices were in fact modified—possibly to deliver bacterial aerosols from helicopters.

In 2003, the U.S. Central Intelligence Agency (CIA) warned that terrorists (including the organization al-Qaeda) could utilize crop dusters and related techniques to dispense deadly biological aerosols. One pamphlet produced by the CIA reported, "Spray devices disseminating biological warfare (BW) agents have the highest potential impact. Both 11 September attack leader Mohammad Atta and Zacharias Moussaoui expressed interest in crop dusters, raising our concern that Al-Qaida has considered using aircraft to disseminate [biological warfare] agents" (*Terrorist CBRN*).

Technical Details

When CW or BW agent is sprayed from a moving aerial platform such as a crop duster, it is described as a line source. As opposed to a point source, in which a munition releases its contents at a single spot, a line source describes a trail of released particles generated by shear and gravity forces caused by the moving aircraft. Crop spraying mechanisms also include pumps. Crop dusters can release a line of particles in their wake over a considerable distance, depending on rate of release, payload, and other factors. Winds approaching the line spread the dispensed particles to form a cloud of increasing size, blanketing the target below. The ultimate behavior and fate of these particles will depend upon the wind velocity, temperature, release height, and average droplet size. In the case of mosquito abatement, for example, the average particle size is approximately 20–50 microns—generally outside the optimum range for inhaled aerosols causing infection with pathogenic organisms. This would be more than adequate, however, for some CW agents such as mustard or VX nerve agent.

The efficient delivery of chemical or biological agents—and the potential effects of such an attack—depend on a number of factors such as the type of agent involved (chemical versus whole cell or virus) and the form, whether liquid suspension (slurry) or dry forms of payload. And even more so than in the commercial utilization of aerial applicators, efficient delivery of BW agents requires proper average particle size, usually considered to be within the range of 5–10 microns. One also needs to consider the engineering modifications necessary to deliver a CBW agent payload versus an agricultural treatment via aerial application. Liquid (slurry) suspensions of a BW agent are probably more practical for bioterrorists in terms of production and delivery. BW agents suspended in liquid, however, are more apt to degrade over time (i.e., they have a short shelf life). Furthermore, using suspensions of microorganisms can create problems during the hydrodynamic flow from holding tank to spray nozzle, potentially clogging the apertures. Flow agents would probably be required to ensure efficient spraying of CW, but especially BW, agents. Dried preparations of BW agents would offer the advantage of a long shelf life, but these also require substantial modifications to the dissemination process.

Among the models that most closely resemble a worst-case scenario—say, an aerosolized release of anthrax bacteria delivered over large, densely populated area—studies on the use of biopesticide (*Bacillus thuringiensis*) for eradication of gypsy moths are instructive. In North America, gypsy moths have been responsible for devastating losses of forests both in Canada and the United States. By spraying forests with aerosolized formulations of *Bacillus thuringiensis* (Bt) bacterial spores, the populations of gypsy moths have been dramatically reduced. After the caterpillar ingests a Bt spore, a toxin generated within the vegetating bacteria destroys the gut lining of the caterpillar. (Unlike some of the more toxic organophosphate insecticides, Bt bacteria are safe to use around animals and humans.) Most of the Bt particles range from about 4–7 microns in diameter, and they have been shown to drift more than a kilometer from the targeted area. Following the application of Bt spores—in many ways similar to *Bacillus anthracis* insofar as their physical properties are concerned—bacteria have been cultured at relatively large numbers inside buildings as well as outdoors.

The challenges for terrorists using crop dusters are the technical hurdles required in manufacturing lethal chemical agents, and especially the none-too-trivial tasks involved in the isolation, growth, and formulation of BW agents. The final product would then have to be configured for dissemination in some form—liquid or dry—compatible with an aerial platform using commercially available equipment. Other factors to consider are the operational details of flying crop dusters near populated areas without being seen. Environmental conditions (inversion) most amenable to disseminating aerosols occur during the evening or early morning hours, and during such times, the likelihood for visual spotting of aircraft from the ground would be poor. But there would still be some risk to the terrorist that something unusual would be seen and that the attack would no longer be covert.

Given adequate warning, and depending on the level of CBW agent detection available on the ground, it would then be possible to warn and medically treat those exposed with collective protection, nerve antidotes, and (in the case of biological agents) prophylactic vaccines and antibiotics. In the event of a chemical attack, detection techniques would be much more rapid, but so would be the effects from the CW agent. Therefore, quick detection, decontamination, and evacuation would be required. In biological attacks from aerosol delivery, there would be more time to react. Viral exposures (e.g., smallpox) can also be successfully treated with vaccines, especially during the first few days following exposure. In short, if the bioterrorist attack is discovered, much of the impact of the biological agents can be mitigated.

The Human Factor in Bioterrorist Use of Crop Dusters

Finally, one must also consider the human element involved in a venture to employ crop dusters to deliver biological weapons. Because of the interdisciplinary nature of CW and BW, with both involving a number of different areas of expertise, such operations leave themselves more vulnerable to penetration by law enforcement and/or intelligence agencies. From a preventative standpoint, human intelligence sources are required to ensure that plots to execute a CBW terrorist event are discovered before they can be carried out. Other considerations include more mundane, but critical, aspects to a WMD terrorist scenario using crop dusters. For example, in the aerial application industry, pilots are highly trained and specialized in the exacting business of spraying agrochemicals, flying sorties at heights as low as 5 feet off the ground. A bioterrorist would be limited, therefore, to hiring someone from within this relatively tight-knit and professionalized community of aviators. Terrorists could obtain their own aviation skills and training elsewhere, but in light of special attention given to the threat from crop dusters in bioterrorism, especially since the September 11 terrorist attacks in the United States, potential terrorists would be hard pressed to do so without attracting attention from interested authorities.

—Eric A. Croddy

See also: Aerosol; Al-Qaeda; Bioterrorism; Line Source; Terrorism with CBRN Weapons

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CS

CS is the code that refers to the riot control agent (RCA) most often used nowadays for crowd control (chemical name ortho-chlorobenzylidene malononitrile). Originally named after its inventors Corson and Stoughton, CS has high potency with a large safety margin. However, if used in confined spaces, and given large enough doses, CS tear gas can be lethal.

—Eric A. Croddy

See also: Riot Control Agents

CYCLOSARIN (GF)

Cyclosarin (cyclohexyl methylphosphonofluoridate) is a less-well-known organophosphate that can be used as a nerve agent in chemical munitions. Also referred to as CMPF (its chemical abbreviation) during its early stage of development by the U.S. military, GF (named for being a continuation of the German series: GA, tabun, GB, sarin, GD, soman, etc.) was devised as a way to create a more persistent agent that was also volatile enough to cause mass casualties. Iraq used GF in its 1980–1988 war against Iran, and it later stockpiled the agent for use in aerial bombs as well on its al-Hussein (modified Scud) missile warheads. During the Iran-Iraq War, Iraqi military units often combined difluor (DF) with cyclohexanol and isopropyl alcohols just before an aerial assault on targets. This procedure formed a near equivalent mixture of GF and sarin (GB) from the respective precursors.

GF is a volatile, odorless, and colorless liquid. It is nearly insoluble in water and is quite stable for storage purposes. The cyclohexanol portion of the molecule, however, has a ring structure that can revert into benzene, making it a less stable compound than other nerve agents. GF is, however, believed to be highly persistent, and splashed GF liquid can last up to a couple of days under normal weather conditions.

Cyclosarin primarily affects the victim through the respiratory tract, although cutaneous and digestive entries can be quite harmful to the body as well. It probably shares a similar toxicity profile to that of sarin (GB). Exposure to a small amount of vapor from cyclosarin can cause dimness of vision, runny nose, chest tightness, and tearing of the eyes within minutes of exposure. As with other nerve agents, exposure to high amounts may lead to loss of muscle control, twitching, paralysis, coma, and death due to the inhibition of acetylcholinestrase (*see* Carbamates). The most common cause of death after acute exposure is respiratory arrest.

—Anjali Bhattacharjee

See also: Binary Chemical Munitions; Nerve Agents

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D

DECONTAMINATION

Decontamination—the removal of contaminants from people, materiel, and the environment—would likely be required in the event of real or suspected nuclear, biological, chemical, or radiological (NBCR) incidents. Each particular weapon type may, of course, necessitate its own specialized decontamination regimen. In general, however, several steps are common to most efforts at decontaminating personnel or physical objects to mitigate the consequences of an NBCR event. Materials (including military equipment) may require extensive cleaning with water, soap, and oxidizing chemicals such as bleach and peroxides. The decision to use solvents or caustic chemicals for decontaminating equipment largely depends on the resiliency of the materials used in the equipment's construction. In the case of treating individual persons, one authority in responses to NBCR events notes, "the use of bleach and water solution in terrorism decontamination is no longer considered an acceptable practice" (Hawley, p. 153). For people, removing all clothing and bathing with soap and water is usually sufficient.

Generally speaking, a hazardous materials (HAZMAT) response approach can be used in the early stages of an NBCR incident. Conventional weapons such as a very large explosive device are not likely to cause significant long-lasting toxicological hazards. In the immediate aftermath of a conventional detonation, however, there will be large quantities of toxic gas (carbon monoxide, nitrogen oxides, and so on) that could cause a short-term danger to personnel. These gases, unless trapped in an unventilated area, will disperse quickly. Conventional explosives also may produce secondary damage at facilities that contain toxic or radiological materials, in which case decontamination may be necessary if the materials are released from containment.

Radiological Decontamination

In the aftermath of a nuclear detonation or radiological event, decontamination would be needed. Fallout from a nuclear device includes smoke and dust particles that emit beta radiation, leading to surface-layer tissue damage if allowed to remain on the skin. But in the event of a true nuclear explosion—that is, an actual fission device—triaging casualties would first require a judgment based on the unlikely, probable, or definitive symptoms of partial or full-body exposure to high-energy radiation (X-rays, gamma rays, and neutrons). Such radiation exposure is instantaneous with the initial nuclear blast itself. Most casualties of severe and immediate nuclear radiation cannot be saved if they have been exposed to large (especially full-body) doses. In these unfortunate cases, cleaning the skin of radioactive fallout is only a palliative measure, although it may be useful to ensure a cleaner environment in the medical treatment facility and for safer burial of remains. Others who may have only received partial exposures can certainly benefit from complete decontamination using soap and water, once their conventional injuries (including, probably, severe burns) have been assessed.

Following radiological events—nonfission explosions that spread radioisotopes in so-called dirty bombs—relatively straightforward decontamination measures such as discarding clothing and bathing can be undertaken to prevent serious injury to exposed individuals and to clean up the environment. Compared to an actual fission explosion, such events are relatively benign in terms of risk from radioactive exposure.

Biological Decontamination

In the event of biological warfare (BW) or bioterrorism, decontamination is largely a secondary issue. The immediate hazard—and the type more

Diluted bleach is one of the most effective decontamination agents, although caution must be used with bare skin. (Reuters/Corbis)

likely to cause mass casualties—is the exposure to infectious aerosols. Following their release, these aerosols quickly degrade in both potency and concentration, lessening the need for deliberate efforts at decontamination. Environmental factors including air currents, inversion conditions, ultraviolet light, and relative humidity all play a role in the decay rate of BW agent aerosols. Over time and distance, at some point the concentration of infectious particles drops below that which is dangerous to humans or animals. When particles have reached the ground surface, they are usually resistant to reaerosolization, and exposure to the elements quickly denatures pathogenic microbes and toxins.

Once individuals become infected, or suspected airborne particles containing BW agents are identified, it becomes important to prevent further exposures (usually by relying on air flow management and use of protective masks). However, following a biological attack, decontamination can become critical when airborne infectious particles can become reaerosolized. The anthrax letters that were sent in late 2001, for example, leaked *Bacillus anthracis* spores through the envelopes, and these generated sufficient infectious particles to cause casualties among U.S. Postal Service workers at the Trenton, New Jersey, Processing and Distribution Center. Contaminated surfaces were also found at the U.S. Senate Hart building in Washington, D.C. Subsequently, these offices were decontaminated using chlorine dioxide gas (ClO_2). In the event of contagious BW agents such as smallpox, secondary transmission is highly likely following initial infections. Here, quarantine and decontamination measures used in hospitals would play significant roles in stopping the spread of disease.

Chemical Decontamination

Although exposure to radiological and biological materials necessitates decontamination, particular immediacy is involved in the event of chemical warfare (CW) agents. Mustard (blister) agent, for example, acts upon the skin as well as the upper respiratory tract. Contaminated victims may have sufficient amounts of chemical on their skin and clothes to present a secondary exposure hazard to first responders. Most casualties from mustard can be mitigated and even avoided by means of physical removal of the material from the exposed skin areas, using absorbent materials to prevent any agent from reaching the skin, and thorough washing. Persistent agents such as VX nerve agent would also require fast and thorough decontamination. With a lethal dose of as little as 15 milligrams on the skin, VX is an extremely dangerous CW agent and must be dealt with using extreme caution. Some events may involve relatively volatile substances, such as hydrogen cyanide or sarin nerve agent. In such cases, preliminary steps toward decontamination can take place by moving victims from the contaminated area into fresh, ventilated air. Off-gassing from clothes and skin can occur, so emergency workers need to be cognizant of secondary exposures.

—Eric A. Croddy

See also: Bleach; Protective Measures: Biological Weapons; Protective Measures: Chemical Weapons

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DEMILITARIZATION OF CHEMICAL AND BIOLOGICAL AGENTS

In the context of chemical and biological weapons issues, demilitarization refers to the elimination of both a country's weapons stockpile and its capabilities to reconstitute that stockpile. Under the 1997 Chemical Weapons Convention, the United States and three other countries declared possession of stockpiles of chemical weaponry: Russia, India, and South Korea. Of these states, Russia had the largest declared stockpile with more than 40,000 tons of chemical weapons, located at seven locations across the country. The United States followed closely behind with just over 30,000 tons.

U.S. Chemical Demilitarization Program

In November 1985, Public Law 99-145 mandated that the Department of Defense destroy 90 percent of the U.S chemical weapons stockpile. In 1992, Public Law 102-484 expanded that program to include complete chemical weapons demilitarization. Although timetables for destruction have shifted, the most concrete plan for demilitarization of the U.S. chemical arsenal was established when the United States ratified the Chemical Weapons Convention. The treaty requires member countries possessing chemical weapons to complete the elimination of their stockpiles within 10 years of the convention's entry into force, which will be April 2007. States that are party to the convention who need to extend this deadline may receive permission from the Executive Council of the Organization for the Prohibition of Chemical Weapons, the secretariat responsible for implementing the various aspects of the treaty.

When the U.S. chemical demilitarization effort began, eight sites in the continental United States and one site in the Pacific housed the tons of nerve and blister agents accumulated since the advent of the U.S. chemical weapons program in World War I. The locations of the U.S. stockpiles were Johnston Island, Johnston Atoll; Blue Grass Army Depot, Kentucky; Aberdeen Proving Ground, Maryland; Newport Army Ammunition Depot, Indiana; Umatilla Army Depot, Oregon; Pueblo Army Depot, Colorado; Anniston Army Depot, Alabama; Pine Bluff Arsenal, Arkansas; and Tooele Army Depot, Utah. Approximately 60 percent of the original stockpile was contained in bulk ton containers. The remainder was in weaponized form (e.g., rockets, bombs, mines, cartridges, projectiles, and spray tanks).

In addition to the actual chemical agents and munitions, the U.S. demilitarization program addresses the destruction of nonstockpile chemical materiel, including buried or chemical weapons, former production facilities, miscellaneous related materials such as containers or testing kits, and binary chemical weapons.

The Army was charged with overseeing the U.S. demilitarization effort. For most of the history of the program, responsibility was split between the Program Manager for Chemical Demilitarization, which supervised the actual weapons destruction program, and the U.S. Army Soldier and Biological Chemical Command, which administered the storage sites, handled safety and security issues, and assisted in the development of emergency response capabilities in communities near the sites. In February 2003, these tasks were combined and assigned to the Chemical Materials Agency.

Disposal of chemical weapons and materiel took many forms in the past. Between 1915 and 1969, weapons the United States wished to discard were sometimes buried, sometimes burned in open pits, and sometimes dumped at sea. By the time these methods were outlawed by the Chemical Weapons Convention, the United States was already well on its way to developing other destruction technologies. Although the Convention does not dictate how weapons are destroyed, it requires that countries utilize methods that are both irreversible and safe for people and the environment.

The decisions regarding what technologies would be employed to destroy the U.S. stockpile required years of deliberation. Incineration was the choice for destruction at five of the nine sites, where the stockpile chiefly consisted of weaponized agents. The Army found incineration to be the best way to dispose not only of the chemical agent, but also of contaminated weapons parts, propellants, and explosives. At the other four sites, an alternative destruction technology, neutralization, was chosen. Because the agent housed at these sites is predominantly in bulk form in ton containers, there is less peripheral materiel that requires destruction than in stockpiles consisting of munitions.

Another challenge for the demilitarization program was to determine where destruction of weapons would take place. The Army presented Congress with three alternatives: on-site destruction at each site; moving all the weapons to a single facility at Tooele, Utah; or a mid-range alternative, dividing the entire stockpile between two regional sites at Tooele and at Anniston, Alabama. Ultimately, it was decided that public safety could be better assured during on-site destruction than during transportation across the country to a single site.

As early as 1970, when the United States was drawing up initial destruction plans for some of its weapons, Congress required that the Department of Health and Human Services conduct a public health review of the disposal plans. The Centers for Disease Control and Prevention's National Center for Environmental Health (NCEH) retains responsibility for this mission. In addition to assisting in the monitoring of emissions, the NCEH has provided informed counsel to the Chemical Stockpile Emergency Preparedness Program, a joint effort of the U.S. Army and the Federal Emergency Management Agency to ensure that emergency responders in communities located near destruction facilities have the proper personal protective equipment and are properly trained should an accident occur.

Destruction Technologies

Important experience for the U.S. chemical demilitarization program was gained during regular disposal of weapons prior to Congress's decision to dismantle the stockpile. Even during the active U.S. program, chemical weapons in the arsenal could not be kept indefinitely because of corrosion or leakage problems. One munition in particular, the M55 rocket, suffered from instability in one of the elements contained in its propellant. Nitrocellulose in the propellant could degrade and cause the weapon to auto-ignite. Disposal of these weapons began in the late 1960s, when they were dumped in the ocean as part of "Operation CHASE" ("Cut Holes and Sink 'Em"). Opposition to the environmental effects of this type of destruction, and public reports such as that released by the National Research Council in 1969 that advised against further ocean dumping, led the Department of Defense to consider other methods.

Incineration and chemical neutralization were the two leading alternatives to dumping munitions in the ocean. Between 1972 and 1976 at Rocky Mountain Arsenal in Colorado, 2,700 tons of blister agent were incinerated and 3,700 tons of nerve agent were neutralized. To further test these two technologies, the Army constructed a pilot facility, the Chemical Agent Munitions Disposal System, at Tooele Army Depot in Utah where the largest percentage of the original U.S. stockpile was located. Based on the results of this testing, the Army chose incineration as its standard or "baseline" destruction technology. Several negative aspects of neutralization discouraged its selection, including the generation of more waste products, inappropriateness for use with certain agents, and the production of hazardous by-products that at that time would have required incineration for disposal. Likewise, incineration was found by a contracted study to be less expensive than the neutralization process.

A full-scale prototype incinerator, the Johnston Atoll Chemical Agent Disposal System, was constructed in 1985. The results of pollution monitoring during test burns in this facility met or exceeded U.S. national standards. The National Research Council issued multiple reports stating that the dangers of continued storage of weapons outweighed the dangers posed by incineration: Incineration destroys the entire weapon, through exposing the munition and the agent to extremely high temperatures.

The incineration process begins when Army personnel remove weapons from the storage area and transport them to the incineration facility in special protective containers, reinforced against fire and explosion. Upon arrival, personnel then inspect the weapons to verify that none of the munitions are leaking. Next, the weapons are placed on a conveyor belt and carried to a reinforced room, where a machine punches a hole in the munition and drains out the chemical agent. The weapon is then broken into pieces. The resultant parts of this process—agent, explosives, weapons parts, and packing materials—are divided and destroyed in separate, dedicated incinerators.

Concerned citizen groups representing the residents of communities located near destruction facilities have questioned the safety of incineration and expressed concern that insufficient consideration had been given to alternative technologies. In response, the Army created the Alternative Technologies and Approaches Program (ATAP) in 1992 to further investigate whether other methods of chemical weapons destruction might be workable at some sites. Chemical neutralization was again considered as an option. The Army found, among other drawbacks to this method, that draining chemical agents from individual munitions was too dangerous and complicated a process to merit changing the destruction method to neutralization at most sites. As some of the U.S. stockpile consisted of agent stored in bulk containers, however, implementation of neutralization was a more practical possibility in those cases. ATAP pursued research, development, and testing of chemical neutralization at two storage sites that contained single types of agent in bulk containers: Aberdeen Proving Ground, Maryland, and Newport Chemical Depot, Indiana. Full-scale neutralization was then adopted at these sites. In 1997, Congress created the Assembled Chemical Weapons Assessment to examine the possibility of also using alternative technologies for weaponized agents, such as the use of microorganisms for neutralization (biodegradation). Neutralization was ultimately chosen to destroy the stocks at two additional sites that had some assembled munitions: Pueblo Chemical Depot, Colorado, and Blue Grass Army Depot, Kentucky.

International Demilitarization

Due to economic difficulties, Russia's chemical weapons demilitarization efforts struggled in the initial years after ratification of the Chemical Weapons Convention. Russia consistently stated that international assistance would be required to destroy its extensive cache of nerve and blister agents. In 2001, the Group of Eight countries agreed to a "10 plus 10 over 10" commitment, in which, during the next 10 years, Canada, France, Germany, Italy, Japan, and the United Kingdom would pledge $10 billion to match a U.S. pledge of $10 billion to help rid Russia and other former Soviet states of their weapons of mass destruction. Some of those funds will assist in the destruction not only of Russia's chemical weapons, but also of the facilities that manufactured them. In 2002, Russia requested and was granted the allowable 5-year extension of the Chemical Weapons Convention's 2007 destruction deadline. It is likely that Russia will be given more time to complete its chemical destruction, probably until 2015.

India met its first two deadlines under the treaty, destroying 1 percent of its stockpile by 1999 and 20 percent of its most dangerous weapons by 2001. South Korea met the first 1-percent deadline but requested and received an extension of the 20-percent deadline during the fourth conference of the Chemical Weapons Convention's parties in 2002.

Biological Weapons Demilitarization

The Biological and Toxin Weapons Convention (BTWC) enjoins parties to destroy all stocks of biological weapons and biological warfare (BW) agents. In 1971, the United States completed the destruction of its offensive biological weapons stockpile. Destroying BW agents is, in many ways, simpler than demilitarizing chemicals. The goal of biological weapons demilitarization is to destroy the ability of BW agents to infect and to cause disease, and killing or denaturing pathogens and toxins can be accomplished by heating (pasteurization), mixing with harsh chemicals (bleach, phenol, alcohols, and formaldehyde), or a combination of steam and chemical treatment.

At facilities such as Pine Bluff in Arkansas, hot steam treatment and formaldehyde were both used to ensure that no organisms survived. In facilities inside the former Soviet Union, such as the biological weapons facility in Stepnogorsk, Kazakhstan, Kazakh workers used calcium hypochlorite in solution to spray down walls, and dry formulation mixed with earth to decontaminate equipment and other materials. Tons of anthrax bacteria that had been buried near the Aral Sea in Kazakhstan by former Soviet biological weapons scientists was finally mixed with calcium chloride and cement in 2003 by the U.S. Defense Threat Reduction Agency and other Department of Defense personnel. None of the anthrax spores were known to have survived following this last burial activity.

—*Claudine McCarthy*

See also: Aberdeen Proving Ground; Biological and Toxin Weapons Convention (BTWC); Chemical Weapons Convention (CWC); Newport Facility, Indiana; Tooele, Utah

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DIANISIDINE

A dye intermediate that is still produced today, dianisidine was among the first toxic chemicals to be used in modern warfare. In World War I, the chemist Walter Nernst recommended that the German military fill 105-mm shells with dianisidine chlorosulphonate (a chemical salt of the dye base). There were two purposes to this strategy: it would serve as a chemical weapon, while conserving explosive materials that were in short supply. The dianisidine salts were impacted as a powder and meant to shower the enemy with a sternatutory (sneezing) powder following detonation using a small charge in the shrapnel round. Although dianisidine is an irritating substance, especially to the eyes and upper respiratory tract, it was demonstrated later in the field that its toxicity was certainly not high enough to cause severe casualties.

On October 27, 1914, the Germans fired some 3,000 shells filled with dianisidine chlorosulphonate near Neuve-Chapelle, France, but none of the attacked British soldiers seemed to have taken notice of any chemical effects. Some have suggested that the TNT charge used in the shells was excessive and decomposed the chemical compound. Not knowing the full assessment of this failed attempt to use dianisidine chlorosulphonate as a weapon, Germany continued to experiment with chemicals in the field, later developing a stabilized artillery round with xylyl bromide. But it would later take the initiative of Fritz Haber, a bitter professional rival of Nernst, to take charge of using chemicals in warfare for Germany. Haber planned the first successful attack using chlorine gas at Ypres, Belgium, in 1915.

—*Eric A. Croddy*

See also: World War I

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DIFLUOR (DF, DIFLUOROMETHYL-PHOSPHONATE)

Difluor is short for difluoromethylphosphonate, usually referred to in U.S. and NATO military code as DF. Going back to the first German synthesis of sarin nerve agent during World War II, diflour has been commonly used to react with other chemicals to form various G-nerve agents. Some processes utilize DF in combination with other compounds in a cascadelike reaction process using dichlor to manufacture sarin (GB). This is called the di-di method. Because of the highly reactive nature of fluorine, process equipment that is resistant to corrosion is usually required. In Nazi Germany, one step of the sarin production process took place in a solid silver vessel. In modern times, highly resistant pipes and reaction vessels, including those made of Hastelloy, steel that is especially designed to handle strong acids, would be needed for producing DF.

In recent decades, DF was the main component in U.S. binary chemical munitions, especially the

155-mm howitzer shell.. Although a number of proposed binary nerve weapons never entered into service, the United States did produce the M-687 GB binary projectile. This contained DF in one container and isopropyl alcohol in another, separated by a thin membrane. Another component, a so-called promoter, was used to push the reaction process to completion. When the shell was launched, the membrane was broken from the initial firing shock, and the rotational spin further mixed the chemical compartments to form sarin. The shell would then release the agent with a specially designed fuse mechanism. As in any chemical reaction, a certain amount of time is required for the reaction to run its course. In the case of the GB binary, this required about seven seconds. Thus, direct-fire use of binaries may have limitations. DF would also have found a role in certain ordnance such as the multiple launch rocket system in combination with other alcohols to form a so-called intermediate volatile nerve agent, but this ordnance was never produced.

DF is also a key compound for the mass production of sarin nerve agent. During the 1980–1988 Iran-Iraq War, the Iraqi military utilized DF in a method that could be described as a crude binary system—a kind of "quick-mix" procedure. They combined DF with the other necessary chemicals on the tarmac while aircraft were being readied to conduct bombing sorties. The chemicals were mixed in the aerial munitions, forming a roughly equal mixture of sarin and cyclosarin (GB/GF) before being dropped on enemy troops or Kurdish populations. DF was also used by the organic chemist of the Aum Shinrikyo cult in Japan to manufacture sarin. DF is listed as a Schedule 1 (B), a strictly controlled precursor in the Chemical Weapons Convention (CWC).

—Eric A. Croddy

See also: Binary Chemical Munitions; Nerve Agents; Precursors; QL

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DIISOPROPYL FLUOROPHOSPHATE (DFP)

Diisopropyl fluorophosphate (DFP) is a toxic organophosphate that was investigated by both the Allies and German scientists during World War II. Its effects are nearly identical to those of other nerve agents in that it inhibits the enzyme acetylcholinesterase. Like the other anticholinesterases, DFP leads to overexcitation of the nervous-muscular system by increased levels of acetylcholine. DFP does have some commercial uses, primarily in the field of medical therapeutics. Though not specifically listed in the Chemical Weapons Convention toxic chemical lists, the use of DFP—as with any other toxic chemical—is prohibited as a means of warfare.

DFP is not nearly as toxic as other recognized chemical warfare (CW) agents such as sarin or VX. Nonetheless, if used in a weapon of mass destruction, large quantities of DFP—a volatile agent that could rapidly spread inside closed areas—would cause many deaths and injuries, and intensive medical treatment would be required for the survivors.

Although German chemists were the first to synthesize and develop the highly toxic organophosphates such as tabun, sarin, and soman (the G-nerve agents), ongoing research in World War II by British scientists followed along similar lines. The principal British researcher in the field of nerve agents was Dr. Bernard Saunders, who often subjected himself to dangerous experiments using these substances in order to evaluate their effects in humans. It had long been known that phosphorus could be poisonous in certain formulations, and fluorine had been recognized early as a highly reactive and caustic substance. During the course of work with these compounds, Saunders discovered that DFP caused one effect typical of nerve agents: pinpoint pupils. Saunders also found that by mixing DFP with mustard, the resultant product could remain liquid at much lower temperatures. British investigators found a relatively simple, almost one-step process for the manufacture of DFP. Thus, a weapon was conceived that not only included a nerve agent (DFP), but also increased the performance of blister agent in winter conditions.

It is not known if modern militaries have continued the production or deployment of chemical weapons using DFP. Its relatively low toxicity probably means that it is not favored by state programs. Terrorists, however, may consider the use of DFP in an improvised chemical weapon. An individual in the United States who held antigovernment attitudes and was probably active in the manufacture of illicit drugs was found with an empty container labeled DFP at his home in 1997. It was probably acquired from a commercial chemical supply house.

Although less toxic than modern nerve agents, DFP is still highly poisonous, with potentially devastating long-term consequences. One side effect of DFP poisoning, most marked in large doses, stems from its targeting of special enzymes in the nervous system; this can result in long-term neuropathy. Thus, although not as deadly as the typical nerve agents developed for warfare, DFP may pose greater long-term problems when it comes to casualty management.

—Eric A. Croddy

See also: Nerve Agents; Organophosphates

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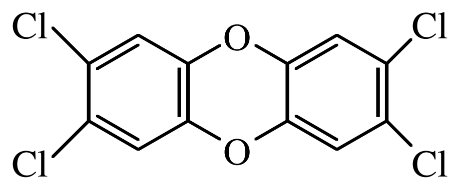
DIOXIN

Dioxin is the generic name for the chlorinated polycyclic hydrocarbon (2,3,7,8-tetrachlorodibenzo-para-dioxin) or TCDD. It is a chemical by-product and contaminant found in many modern sources, including the herbicide Agent Orange, which was manufactured during the Vietnam War.

In its pure form, dioxin is relatively toxic. Its toxic effect, however, is dependent upon the species of animal exposed to the compound. In small concentrations such as those found from industrial by-products, little evidence has been shown to link dioxin directly with human disease. In 1986, for example, Michael Gough wrote, "the position of the majority of scientists who have examined the human health effects of dioxin is that little or no harm has been done" (Gough, p. 254).

Some have suggested, however, that dioxin could be used as a mass casualty weapon. For example,

Figure D-1: Dioxin
(2, 3, 7, 8-tetrachlorodibenzo-para-dioxin)



during the 1970s, one writer postulated that dioxin could be used as a chemical warfare (CW) agent (Holmberg, p. 211). There is no evidence in the open literature to suggest, however, that dioxin has ever been seriously considered as a potential component in chemical weaponry. For the modern chemical industry, it would not be particularly difficult to mass-produce dioxin and to divert it for military use. At the same time, the conflicting data of dioxin's real or alleged toxicity in humans has probably led CW scientists to turn to other proven chemicals for use in warfare.

The notion persists that exposure to Agent Orange has been the cause of cancer and birth defects for Vietnam veterans and their families, including Americans, South Koreans, and Vietnamese civilians. Dioxin was formed as a contaminant during the manufacture of 2,4,5-T, a major component (50 percent) of Agent Orange, and it was implicated by U.S. veterans groups and the government of the Socialist Republic of Vietnam as the etiologic agent. Yet it is extremely difficult (if not impossible) to find adequate studies to prove a link between dioxin and veterans' illnesses. The most recent studies suggest that U.S. veterans who were exposed to dioxin from Agent Orange may have higher rates of diabetes than other populations. Even in the case of these findings, however, the results could be confounded by other non-dioxin-related risk factors such as obesity.

Dioxin and its alleged role as a toxic environmental contaminant continue to stir debate in scientific and other realms. Because of its ubiquitous nature as a very low-level presence in a number of consumer products, especially bleached paper and other goods, some have suggested that there is "no safe level" of dioxin. Such proclamations, however, have no supporting facts in the study of dioxin to date, or even in the field of toxicology itself. Still, prudence would dictate that levels of dioxin should be kept at below the point at which toxic effects

Dioxin can occur in many settings due to both natural and industrial processes. Its toxicity, however, is often exaggerated. (Bettmann/Corbis)

would be seen in human populations. When it comes to determining public health policy, knowledgeable toxicologists—and cautious governmental administrators—must determine how low these concentrations should be.

—*Eric A. Croddy*

See also: Agent Orange; Herbicides

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DIPHOSGENE

Diphosgene is also known as trichloromethyl chloroformate. It is a highly toxic lung irritant that first found use as a chemical warfare (CW) agent during World War I. Despite its well-earned notoriety as a war gas, diphosgene does not have the degree of toxicity or ease of acquisition that would make it a likely CW agent for use in weapons of mass destruction. Nor are there significant sources of the chemical in modern industry.

Diphosgene was first used by the German military at Verdun, France, in May 1916, probably as a response to the French use of phosgene in February of that same year. Diphosgene was later used by the French army in World War I under the code name Surpalite. In one World War I attack, 100,000 diphosgene shells were fired during a single engagement near Verdun. Diphosgene was probably the principal killing "gas" used in artillery shells during that war. In terms of total casualties, however, diphosgene was not nearly as significant as mustard gas in World War I.

Diphosgene was named on the apparent belief that it was the exact double of phosgene; that is, that phosgene ($COCl_2$) multiplied by two equaled diphosgene ($C_2O_2Cl_4$). Such a relationship is in fact spurious, as the chemicals are very different from each other in terms of chemical and physical properties. In terms of their action as lung irritants, however, their effects are similar. Fritz Haber, generally considered the father of modern chemical warfare, ranked diphosgene at an index of 500 in terms of toxicity compared to 450 for phosgene.

An oily liquid, diphosgene was derived by German military chemists. The toxic effects of diphosgene mirror those of phosgene: interacting with vital molecules and enzymes in the pulmonary system, causing pulmonary edema by irritating lung tissue. At sufficient concentrations, diphosgene has an odor like that described for phosgene, often characterized as newly mown hay. Treatment options for diphosgene exposure are similar to those for chlorine or phosgene intoxication; little can be done beyond supportive care and assistance in breathing.

Diphosgene remains liquid at a larger range of temperatures than other CW agents used in World War I. This makes it easier to fill munitions with diphosgene. Once fired at targets and after the detonation of shells, however, diphosgene still proved to be quite volatile, and lethal concentrations on the battlefield were difficult to create. It also was found that diphosgene was prone to decompose following the explosion of its delivery munitions. In addition, production of phosgene during World War I was easier than that of diphosgene.

As is the case of phosgene and some other World War I–era compounds, it is unlikely that diphosgene will pose a significant modern military threat. Some have suggested that diphosgene liberates chloroform upon contact with protective filters and that it perhaps defeated early gas masks. The Chemical Weapons Convention lists diphosgene (as it does phosgene) a Schedule 3 compound due to its potential use as a weapon.

—Eric A. Croddy

See also: Choking Agents (Asphyxiants); Phosgene Oxime (CX, Dichloroform Oxime); Phosgene Gas (Carbonyl Chloride); World War I

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DUAL-USE

U.S. technology and hardware items with both civilian and military applications are considered dual-use items under the U.S. Export Administration Regulations (EAR). In accordance with the EAR, all dual-use items are evaluated and listed on the Commerce Control List, which is used to determine whether a dual-use item may be exported from the United States. The Bureau of Industry Security in the Department of Commerce is responsible for administering the EAR, licensing exports, providing outreach services to U.S. industry, and enforcing the provisions of the EAR through civil and criminal legal actions against violators.

In some instances, dual-use items may require export authorization from the Department of Commerce. In determining whether a license is required, EAR guidelines consider both the technology to be exported and the country of destination. As a general rule of thumb, dual-use exports are more highly restricted to countries considered to be terrorist or proliferation risks.

Export restrictions on dual-use items are subject to review and change. Accordingly, the Commerce Control List is altered several times each year. In some cases, restrictions on exporting specific dual-use items are relaxed as the underlying technologies become more common or widespread throughout the world. Restrictions placed on individual countries also are reviewed and changed periodically, based on the proliferation and terrorist risk each country poses. Changes are coordinated through the Departments of Commerce, Defense, and State, as well as other federal organizations where applicable.

—Lawrence R. Fink

See also: Australia Group; Chemical Weapons Convention (CWC); Fermentation; Lyophilizers; Precursors

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DUGWAY PROVING GROUND

Dugway Proving Ground is a chemical and biological weapons facility that once served as a vast test site for U.S. chemical and biological weapons. It is located in the Great Salt Lake Desert, about 80 miles southwest of Salt Lake City, Utah. The Dugway facility, 25 percent larger than the state of Rhode Island, was opened in 1942 as the United States, which had just entered the Second World War and feared the use of chemical weapons by the Axis powers, looked to expand its own production and testing facilities. Closed when the war ended, it was reopened and enlarged in 1950 in response to the outbreak of the Korean War. Biological weapons were tested there for the first time in 1953.

After it became a permanent installation in 1954, the infrastructure of Dugway grew over the years in response to the Cold War. As new and more effective chemical and biological agents were developed in U.S. government laboratories (primarily at Fort Detrick, Maryland), they were sent for testing at Dugway. Most testing involved the use of animals such as goats. In outdoor tests, animals would be tethered in test grids at increasing ranges from the release of agents. One such test of anthrax resulted in a section of Dugway being permanently contaminated and set off-limits.

Such open-air testing, however, was brought to a halt after an airborne dispersal experiment went awry in March 1969. The aircraft in question was carrying canisters that were designed to open and release VX nerve agent over the proving ground. The aircraft, however, continued to release agent as it turned away and left the confines of the proving ground. The agent contaminated an area 20 miles north of the perimeter, killing more than 6,000 sheep grazing there. The incident was worsened by the fact that, for more than a year, the military denied any responsibility for the deaths, noting that the dead sheep showed atypical signs of nerve agent poisoning. This incident alerted the U.S. public to the dangers of the production, storage, and testing of chemical and biological weapons and struck a chord with the burgeoning environmental movement. It also led to increased interest in more public accountability when it came to activities undertaken at the Dugway facility.

Although open-air testing ended at the facility, Dugway remained the prime U.S. site for the testing of chemical and biological warfare agents within facilities that could safely contain dangerous agents. In 1976, however, fifty wild horses died on the proving ground in mysterious circumstances. The military again denied responsibility for the deaths of these animals.

Today, Dugway is part of the U.S. Army Test and Evaluation Command (TECOM), headquartered at Aberdeen Proving Ground, Maryland. Some 500 people are still employed at Dugway, the majority of them civilian scientists. Most of their work is concerned with testing defensive measures against chemical and biological agents, but research also is conducted to perfect battlefield smokes and obscurants.

—*Rod Thornton*

See also: United States: Chemical and Biological Weapons Programs

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EA2192

EA2192 (named after the U.S. Army's Edgewood Arsenal) is a VX analogue. The chemical name for EA2192 is S, 2-(diisopropylaminoethyl) methylphosphonothioic acid. Because it possesses both high toxicity and a chemical structure very similar to VX nerve agent, EA2192 is classified as a Schedule 1A toxic chemical under the Chemical Weapons Convention (CWC). It is unknown whether EA2192 has been produced or utilized as a chemical weapon in the past or present. The toxicity of technical or pure EA2192 is on par with that of VX.

This compound is of recent interest given U.S. efforts to destroy its remaining stockpile of VX nerve agent. Due to environmental and other technical concerns, the U.S. Army decided that bulk VX would be chemically neutralized rather than sent straight to incineration. When VX is mixed with hot sodium hydroxide (NaOH), most of the toxic chemical warfare agent is hydrolyzed (broken down by water) into nontoxic compounds. Still, as VX is hydrolyzed, a small quantity of EA2192 is formed as a by-product. The potential hazard posed by EA2192 during the neutralization process is mitigated by the formation of a nonvolatile salt. Furthermore, the so-called hydrolysate remaining after neutralization has less than 0.1 percent by weight concentration of EA2192. The subsequent and large dilution factor makes the resultant hydrolysate an irreversible end product of VX destruction, and negligible amounts of EA2192 are eventually biodegraded by microorganisms found in nature.

—Eric A. Croddy

See also: Chemical Weapons Convention (CWC); Demilitarization of Chemical and Biological Agents; V-Agents

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E

EBOLA

See Hemorrhagic Fevers

EDGEWOOD ARSENAL

See Aberdeen Proving Ground

EMPTA (O-ETHYL METHYLPHOSPHONOTHIOIC ACID)

EMPTA, for O-**e**thyl **m**ethyl**p**hosphono**t**hioic **a**cid, is a precursor for V-type nerve agents. EMPTA has few, if any, commercial uses. EMPTA is useful as a VX precursor, however, because although EMPTA is not especially toxic, much of the difficult chemistry required to manufacture the toxic nerve agent is already present in the EMPTA molecule. It is suspected that Iraq used EMPTA to produce VX, and other countries (e.g., the Soviet Union) may have also used EMPTA to create their chemical arsenals.

According to the schedules of precursor chemicals restricted by the 1993 Chemical Weapons Convention (CWC), EMPTA would be included (albeit not explicitly) in the Schedule 1 category. EMPTA has been a noted precursor for CW agents in the open literature since at least 1986.

Because Iraq had been using EMPTA as a means to produce VX nerve agent, this precursor had been on the current watch list by Western intelligence agencies for about 2 years before a soil sample was obtained in Khartoum, Sudan in late 1997. This sample was taken near the grounds of Al Shifa, a pharmaceutical plant that was ostensibly in the business of producing medicines for humans and livestock. After U.S.-based laboratory analysis, it was determined that the soil contained EMPTA. Other and more circumstantial evidence had also pointed to production of VX or a similar type of nerve agent at Al Shifa. According to newspaper reporting, Emad al-Ani, an important figure in Iraq's development of chemical weapons (the "father" of Iraq's VX program), had contacts with officials from Al Shifa.

Due to this evidence, and as a means to signal its capability to strike back at terrorists following two large bombings at U.S. embassies in Africa, the United States launched a cruise missile attack in 1998 against a suspected Osama bin Laden training camp in Afghanistan and at the Al Shifa factory, which was demolished by the attack.

Chemical weapons experts have since suggested that Fonophos, an organophosphate insecticide, had been used quite often throughout Africa and could have been "misinterpreted" for EMPTA. An unnamed spokesman from the Organization for the Prohibition of Chemical Weapons also said that Mobil Corporation and the International Chemistry Industries of America had published reports describing how EMPTA had possible commercial applications. Thomas Carnaffin, a British engineer who had helped to design the Al Shifa plant from 1992–1996, said that he never saw evidence of VX or its precursors being made at Al Shifa Pharmaceuticals, and he claimed that security was very lax during the time he was technical manager at the facility.

As to the veracity of the evidence and the appropriateness of the U.S. military response, the attack on Al Shifa remains controversial to this day.

—Claudine McCarthy

See also: Al-Qaeda; Al Shifa; Osama bin Laden; V-Agents

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ENTEROVIRUS 70

Human enteroviruses are a large family of ubiquitous viruses causing a spectrum of both common and uncommon illnesses with flulike symptoms, particularly among infants and children. After influenza, they are second only to the common cold as a source of flulike ailments.

Enterovirus-70 (EV-70) can cause acute hemorrhagic conjunctivitis (AHC), a highly contagious, self-limiting inflammation of the eye. Following an incubation period of 12 hours to 3 days, exposure causes a sudden onset of conjunctivitis with lid swelling, subconjunctival hemorrhage, and marked eye pain without systemic effects. These symptoms usually resolve within 1 to 2 weeks. Although not fatal and not listed as a high-priority bioagent by the Centers for Disease Control, AHC can be incapacitating.

AHC was first reported in Ghana and Indonesia in 1969 and was called Apollo conjunctivitis. A new enterovirus, EV-70, was identified as a cause of AHC in 1972. EV-70 was subsequently responsible for a pandemic of the disease in 1980–1982, during which it spread to tropical areas of Asia, Africa, Central and South America, the Pacific islands, and parts of Florida and Mexico. Small outbreaks associated with EV-70 have been reported in European eye clinics, among refugees in North America, and among travelers returning to North America.

UN Special Commission (UNSCOM) Chairman Richard Butler reported in a March 18, 1999 letter to the UN Security Council about inspections of a facility in Daura, Iraq, where research was undertaken on viral agents for Iraq's biological warfare program, including enterovirus.

This virus may be reemerging. EV-70 has led to various epidemics in India, including a major outbreak of AHC in Delhi, India, during the rainy season in August and September 1996. In August 1999, the Ministry of Health of Romania reported an outbreak of aseptic meningitis. The CDC and the Robert Koch Institute in Berlin, Germany, assisted in the investigation, and the responsible agents were found to be three separate enterovirus serotypes.

EV-70 only infects humans. It is shed in tears and spread via fingers, towels, clothing, and so on. As the virus can survive for weeks in water and other fluids, indirect transmission via food and water is seen in areas of poor sanitary conditions and overcrowding. Infants in diapers are particularly efficient transmitters of infection, as direct contact with feces occurs with activities such as diaper changing. This is a virus with mysterious epidemiological characteristics. It is responsible for sharp, severe outbreaks of intense conjunctivitis, which seem to cease as suddenly as they arise. In temperate climates, infections occur mainly in the summer and fall and can affect more than half of a community.

—*Beverley Rider*

See also: Iraq: Chemical and Biological Weapons Programs

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EQUINE ENCEPHALITIS (VEE, WEE, EEE)

Equine encephalitis (also referred to as the equine encephalitides) is a group of diseases affecting both horses and humans, caused by a family of viruses that are transmitted by the bite of mosquitoes. One of these viruses, Venezuelan equine encephalitis virus (VEE virus), was developed by the United States into a standardized biological weapon before the renunciation of biological weapons by the United States. Other viruses of this family, such as western equine encephalitis (WEE), eastern equine encephalitis (EEE), and St. Louis encephalitis (SLE), are less likely to be developed as biological weapon agents as they do not share the advantages of VEE in terms of infectivity. However, they too may be considered potential viruses for weaponization.

History and Background

The equine encephalitis viruses and the related Japanese B encephalitis virus were investigated as potential BW agents during WWII by the U.S. BW program. Immediately following WWII, the U.S. weaponization effort concentrated on VEE because of the large number of laboratory infections it caused and its ability to grow well in the laboratory.

VEE was developed primarily as an incapacitating BW agent because, in healthy adults, death or permanent disability from infection was very rare, but the disease was severe enough to incapacitate its victims for several days. Natural epidemics of VEE, however, showed considerable variations in the severity of the human disease, with significant mortality and permanent neurological damage in infants and children and indications that infection caused fetal malformations. Some strains appeared considerably more lethal, and these were investigated as lethal BW agents.

Technical Details

The VEE virus can be transmitted by the bite of an infected mosquito or by inhalation of an artificially generated infectious aerosol. In nature, VEE normally exists in a rodent-mosquito cycle that causes human cases only sporadically in restricted localities. When mutations occur that allow the virus to replicate in horses, large-scale equine outbreaks occur that can kill thousands of horses, spread for hundreds of kilometers, and persist for years. During these epizootics, infectious mosquitoes spread the disease to humans, sometimes causing human outbreaks.

The U.S. Army developed an attenuated live-virus VEE vaccine that was protective in humans but provoked reactions nearly as severe as the disease itself. This vaccine was never used in humans to control VEE outbreaks, but it proved to be an effective veterinary vaccine.

Current Status

VEE remains on the U.S. Centers for Disease Control and Prevention (CDC) Category B list of potential biological agents, although terrorists or hostile states would seem unlikely to choose an agent with such generally benign effects as a weapon of terror or mass destruction.

As a biological weapon, contemporary information about the genetics of VEE indicate that it is considerably less controllable than was believed during the period when it served as a U.S. biological agent. U.S. BW doctrine called for the use of noncommunicable agents to allow precise control of the extent of an outbreak in tactical scenarios in which an incapacitating BW agent such as VEE would be used. Yet, in retrospect, it has been found that many outbreaks of VEE that were once considered natural were in reality the result of the "escape" of laboratory strains, either through inadequately inactivated veterinary vaccines or other, uncharacterized environmental releases from virology laboratories. This propensity of isolated releases to develop into poorly controllable regional outbreaks reduces the attractiveness of VEE as a BW agent.

Brains from dead crows are tested for Eastern Equine Encephalitis (EEE), as well as West Nile Virus. (Wyman/Corbis Sygma)

After many spontaneous outbreaks in Latin America during the period 1938–1975, VEE outbreaks became quite rare after the mid-1970s.

Its benign effects make unmodified VEE virus unappealing for use as a terrorist BW agent. The fact that it can be grown to high titer (strength) and be delivered by direct aerosol suggests the possibility that it might form a basis for a molecularly modified BW pathogen. Its genome is small, and genomic variations are highly limited by the stringent conservation of its protein products, making such a "genetic vector" role problematic. The Soviet BW program attempted to incorporate VEE genes into a vaccinia virus, apparently in an effort to develop a better VEE vaccine.

—Martin Furmanski

See also: Biological Warfare; Centers for Disease Control and Prevention (CDC); United States: Chemical and Biological Weapons Programs

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ETHIOPIA (ABYSSINIA)

Italy's use of chemical weapons in Abyssinia (now Ethiopia) in 1935 is the only time a European power has used such weapons in a conflict since the end of World War I. This action contravened the Geneva Protocol of 1925, which Italy had signed and ratified, and which outlawed the use of gas and bacteriological weapons.

In October 1935, the Italian dictator Benito Mussolini was anxious to expand his African colonial empire. From bases in two Italian colonies in east Africa, Eritrea and Somaliland, Mussolini's forces invaded the neighboring independent state of Abyssinia. The Ethiopian troops, under their leader, Emperor Haile Selassie, despite being outgunned and poorly equipped, put up stiff resistance against the Italian invaders. Lack of progress in what the Italians expected would be an easy advance caused them to think about employing poison gas. The use of such weapons, despite their illegal nature, had been considered by Mussolini even before the invasion had begun. He had previously cabled his generals: "Authorized [to] use gas as last resort in order to defeat enemy resistance and in case of counterattack" (Coffey, p. 263).

The "last resort" apparently had been reached on December 23, 1935. On this day, a body of Ethiopian troops came under attack from Italian planes. Aerial bombardment was nothing new to these soldiers, but their commander noted that the planes dropped "strange containers that burst open almost as soon as they hit the ground or the water, releasing pools of colourless liquid" (Coffey, p. 196). Those splashed by the fluid "began to scream in agony as blisters broke out on their bare feet, their hands, their faces." Those that rushed to the river to alleviate their suffering with water found little relief, because the river was polluted with the same substance. Men took hours to die. Local peasants who drank water from the river shared the same fate as the soldiers who had been attacked with mustard agent.

Blister agents, such as mustard gas, were eventually employed widely by the Italians. Canisters gave way to the use of aerial sprays created by planes in formation. Whole areas became covered in blister agents that created a long-term danger for the barefoot Ethiopian soldiers and peasants. Grazing animals were also affected by the agent. The use of such agents by the Italians—who always denied employing them—proved very effective in the war. They began to achieve easy victories as Ethiopian morale crumbled in the face of chemical attacks. By the war's end in May 1936, when the Italians occupied the capital of Addis Ababa, some one-third of all Ethiopian casualties (15,000) had probably been caused by chemical weapons.

The international community was shocked by the Italian use of chemical weapons, and the League of Nations applied sanctions on the country. These sanctions, in keeping with the weak nature of the League in the 1930s, were soon dropped.

—Rod Thornton

See also: Mustard (Sulfur and Nitrogen)

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EXPLOSIVES

Explosives are energetic materials that expand or decompose quickly, giving off large amounts of heat and/or rapidly expanding gases. Black powder was probably the earliest explosive, used in warfare by the Chinese as early as 920 C.E. Commonly used explosives in both civilian engineering projects as well as warfare—including terrorism—are trinitrotoluene (TNT), nitroglycerine (component in dynamite), and ammonium nitrate fuel oil (ANFO) mixtures.

High explosives fall into three general categories based on their sensitivity: primary, secondary, and tertiary. A primary explosive is one that will detonate upon exposure to heat, shock, friction, flame, or static discharge. They are generally extremely sensitive and are used in small quantities as detonators to initiate secondary explosives.

Secondary explosives cannot be detonated readily by heat or shock. Several explosives in this category can be burned without detonating, and are relatively insensitive to shock, making them safer to handle than primary explosives. While a detonation may spontaneously occur, it is far less likely than with a primary explosive. In most cases a primary explosive must be used to initiate detonation of the secondary explosive. Thus, a "train" is needed for one group of explosives to link detonation to another less sensitive group of explosives.

The third group, tertiary explosives, is the least sensitive. ANFO falls into this category. Spontaneous detonation isn't likely unless several factors occur. In some cases a secondary explosive, functioning as a booster for the detonator, must be used to induce detonation. This creates still another link in an explosives train.

High explosives create two types of effects on the target material: shattering and heaving. All have both characteristics but tend to have one more than the other. Shattering is inducement of shock waves into the material that break up its composition. An example would be using plasticized explosives (such as C-4 or Semtex) to "cut" through steel; the target is destroyed but attached material inches away remains intact. Explosives with extremely high detonation rates are normally used for this type of activity. Heaving is the physical movement of material due to the expansion of gases from the explosion. An example would be using ANFO in earthmoving operations. It compresses rock beyond its elasticity threshold, thereby breaking it up. Explosives with low detonation rates are used for this sort of activity.

—Dan Goodrich and Eric A. Croddy

See also: Ammonium Nitrate Fuel Oil (ANFO); C-4; Plasticized Explosives; TNT

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F

FENTANYL

The synthetic opiate fentanyl and its derivatives are among the many different pharmacological substances investigated for the purpose of incapacitating personnel. Especially during the Cold War, a great deal of research was expended by the United States and the former Soviet Union on chemical substances that would not necessarily kill, but would instead merely incapacitate the enemy. In the offensive U.S. chemical warfare (CW) program of the 1950s and 1960s, a large number of pharmacological substances were investigated for their potential as incapacitants, including depressants, hallucinogens (e.g., LSD), belladonna drugs (scopolamine, BZ), and the opiate derivatives. The opiates in particular, such as morphine, fit receptors in the human brain and nervous system as a key would fit into a lock, releasing painkilling endorphins and inducing a state of euphoria. Given the right amount, opium-based drugs can also induce sleep and unconsciousness. One U.S. Army study in 1989 used carfentanil—a synthetic opiate related to Fentanyl—and saw a nearly tenfold increase in its potency when delivered in aerosol form to experimental animals.

The properties of poppy-derived medicaments had been known for many centuries, and morphine had already found some use as an anesthetic agent by the late 1800s. However, the use of morphine as a total anesthetic (inducing unconsciousness, versus local, in which the patient is awake) sometimes led to deadly complications both during and following medical procedures. In 1939, the synthesis of meperidine and its improved safety profile led to renewed interest in the use of opiates for anesthesia. But arguably the most important development was the synthesis of fentanyl, its structure first patented by Paul Janssen in 1963. Fentanyl remains among the more commonly used compounds in combination with other drugs, or even by itself, for anesthesia. Large doses of fentanyl, however, can increase risks for complications, particularly in terms of respiratory depression during recovery.

Recently, a number of different analogues based on fentanyl have been introduced, including sufentanil, alfentanil, and remifentanil for use in anesthesia. If drugs like the belladonna alkaloids could be utilized in chemical weapons, some CW specialists have wondered if opioid derivatives could also play a role in warfare or in certain tactical operations. During their own research, however, U.S. military chemists found that the dose of opiate-related drugs needed to cause the desired degree of incapacitation was not far from their lethal dose. With such a narrow margin of relative safety, there was not much rationale for using these substances as incapacitating weapons.

Although considered unfit for large-scale production or weaponization, opiate drugs like fentanyl may have had some applications in specialized warfare or covert operations. During his tenure in southeast Asia (1966–1968), retired Major General John K. Singlaub recalls a time when the military use of fentanyl or similar drugs was considered for tactical roles in Vietnam. The U.S. Military Advisory Command (MAC) Studies and Observation Group (SOG) was assigned, among other things, to gather intelligence by capturing enemy officers for interrogation. This proved to be among the most daunting challenges that Singlaub and others faced along the Ho Chi Minh trail, where North Vietnam shuttled logistical and other support to the Viet Cong irregulars in the South. Although most of these Vietnamese carrying supplies on foot or on bicycles were low-ranked soldiers—mainly peasants pressed into labor—some high-ranking North Vietnamese Army officers were often also present. Often, when

SOG units engaged these caravans, it would quickly turn into a desperate firefight. General Singlaub wondered if there was a way to temporarily knock out some isolated individuals while scattering away the irrelevant logistical support units. He could then bring these NVA officers in for questioning. One of the plans was to utilize some type of tranquilizing dart with fentanyl or a related substance. In the end, however, the science advisor to General Westmoreland, commander of the U.S. military in Vietnam, did not approve of this venture, and only CS (a riot control agent) was ever approved for the southeast Asian theater of operations.

In October 1997, the Israeli Mossad (intelligence bureau) used fentanyl in either an assassination attempt or a snatch-and-grab operation that subsequently went awry. In this incident, Israeli intelligence operatives (including one physician) traveled to Jordan and followed Khalid Mishal, a Jordan-based Hamas (Palestinian-based terrorist organization) leader, in a car. The plan was to deliver fentanyl in a spray that would be absorbed through Mishal's ear, but Khalid Mishal was able to escape. He was reportedly affected by the drug, however, and required significant medical attention afterward.

On October 23, 2002, during an evening performance at a Moscow music theater, some 50 Chechen terrorists, equipped with firearms as well as large quantities of explosives, seized the venue and the 800 people inside. The terrorists threatened to kill everyone inside unless Russia ended the war in Chechnya. Although the Chechen militants agreed to release some of the hostages during the first couple of days, negotiations with the Russian authorities eventually stalled. Just before dawn on October 26, Russian special police units resorted to using an incapacitating gas based on the drug fentanyl to end the crisis. All of the Chechen militants were immobilized, and were shot and killed when Russian police finally stormed the theater. At first it appeared that most of the civilian captives survived. But although the operation was largely a success, 129 people eventually died from the effects of the gas, most of these being hostages. The fact that so many died because of fentanyl (or a related derivative) poisoning has been the source of some controversy about how the Moscow theater operation was handled. During the 2003 review conference of the Chemical Weapons Convention, the Moscow theater incident also led to increased discussions in the Organization for the Prohibition of Chemical Weapons in The Hague concerning the legality of incapacitants and riot control agents.

—Eric A. Croddy and Anthony Tu

See also: Bioregulators; Riot Control Agents

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FERMENTER

Fermenters, or bioreactors, have wide and varied civilian applications in basic research and in large-scale chemical and biological processes in the pharmaceutical, food and beverage industries, and at wastewater treatment facilities, among many other applications. Although the understanding of fermentation was originally confined to the production of alcohol, it has since been found to be possible to utilize microorganisms (e.g., bacteria, fungi, and yeasts) for the efficient manufacture of other carbon compounds. Fermentation can suggest biological activity in which metabolism takes place in an oxygen-free environment (anaerobic). In recent years, fermentation has sometimes been understood to include such a process under aerobic (with oxygen) conditions as well. Virus production, especially for the production of vaccines, can also be accomplished using specialized cell lines in fermenters (also referred to as bioreactors).

Fermenters would be a necessary part of a biological weapons program, especially for the production of bulk agents—bacteria, toxins, and viruses. Past BW programs, such as those in the United States and former Soviet Union, used very large fermenters to produce biological agents such as anthrax. For example, at Stepnogorsk in Kazakhstan, the Soviet BW program utilized 20,000-liter fermenters. Transfers of certain types of fermenters are regulated by national export controls, including an informal export arrangement known as the Australia Group. The ubiquity of fermenters in a variety of commercial enterprises, from foodstuffs to vaccines, however, makes the control of fermenters problematic if not impossible.

Typical fermenters used to produce vaccines, for example, are likely not to differ when used to produce BW agents. In the case of diphtheria vaccine, for example, bacteria are grown and the toxin responsible for disease—diphtheria toxin—is detoxified following separation from the biomass. Typical production of other toxoids for childhood vaccinations, including against tetanus, might begin in a fermenter of about 1,000-liter capacity. The bacteria are cultivated under controlled conditions with sufficient growth media in a sterile environment. Although viruses require living cells to reproduce, this technique has also given way to using large fermenters to achieve large amounts of cells for viral production. This approach has made the manufacture of viral-based vaccines much more economical.

Among other intermediate and final products produced in processes involving the use of fermentation are acetone, amino acids, antibiotics, beer, cellulose, citric acid, enzymes, and perfume. In beer production, wort—the filtration product derived from a rice and barley mixture following heating—is fermented using yeasts such as *Saccharamyces cerevisiae.* During wastewater treatment, sludge is collected following preliminary treatment and separation. The sludge is then typically transferred into an enclosed tank (an "anaerobic digester"), where bacteria partially convert it into methane gas. The unconverted portion of the sludge may then be used in fertilizers, incinerated, dumped, or buried, and the methane may be collected for use as fuel.

The terms *fermenter* and *bioreactor* are often used interchangeably. Fermenters are vessels in which fermentation occurs through the optimized distribution of gases, liquids, and nutrients at selected temperatures and pH levels; the fermentation vessels may range in size from a few milliliters to tens of thousands of kilograms (liters). Fermentation processes generally require carbon and nitrogen sources, as well as other growth factors such as vitamins and minerals. There are a wide variety of fermenters differing in design and function. Some involve the immobilization of cells or their emplacement behind a membrane through which nutrient media may then be passed. Other fermenters are batch reactor vessels that are periodically emptied and sterilized before reuse. Still other fermenters operate continuously as feedstocks are added and product removed.

There are two broad types of industrial production configurations involving the use of fermenters. One is a traditional single-purpose plant, such as those found in the petrochemical industry, where large volumes of commodity chemicals are produced on a continuous basis. The other is a smaller, more versatile facility where smaller quantities of fine chemicals are produced to order in batch mode. Such facilities may, for example, use lines of automated microreactors capable of producing large volumes of specialized chemical or biological substances over a period of days or hours.

One of the most significant trends involving the use of fermenters and their possible application for the production of chemical or biological warfare agents is that the distinction between chemical and biological processes is increasingly blurred. This is reflected in the increasing use of biocatalysts (microbial enzymes) in the chemical industry, including for the large-scale production of cosmetics, food products, and plastics. Catalysts are often required to accelerate or induce desired reactions. The chemical and biotechnology industries have a growing interest in the research and development of biocatalysts because their use can reduce production costs. Biocatalysts, usually enzymes or enzyme-based substances, are more selective in their end products than traditional chemical processes. Processes involving the use of biocatalysts also generally involve fewer intermediate production steps than traditional chemical synthesis routes.

—John Hart

See also: Dual-Use

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FOOT-AND-MOUTH DISEASE VIRUS

Long a scourge in animal husbandry, foot-and-mouth disease (FMD) is especially worrisome for modern agriculture industries that employ dense-animal farming. FMD is generally not a lethal disease in animals, nor does foot-and-mouth disease virus (FMDV) directly affect humans, although infections do occur (generally in a laboratory setting, and only with considerable effort). FMDV affects animals with cloven hooves, such as pigs, cattle, sheep, goats, and giraffes, but not single-toed animals such as horses. Infected animals generally develop painful sores (starting as vesicles) in the mouth. Vesicles also form at the hoofs and between the digits, with shedding of epithelium. Animals thus affected do not thrive. In cattle, sores can develop on the teats, ruling out milk production, at least during the course of disease. Most animals ordinarily will survive FMDV infection, although some strains of the virus are more potent than others (e.g., many pigs died from FMD in the 1997 Taiwan FMD outbreak). Death in animals from FMD is usually caused by damage to heart muscle, and surviving animals can suffer some long-term effects, including diabetes mellitus.

FMDV has been investigated as a potential BW agent by the United States, the Soviet Union, Iraq, and probably other states. During the Second World War, research was conducted on FMDV by H. W. Schoening at the U.S. Department of Agriculture as a joint War Research Service project with the United Kingdom, although little seemed to have resulted from this project.

Upon confirmation of an FMD outbreak in a country member of the Office International des Epizooties (OIE), the International Office of Epizootics, exports of domestic animals and related products are banned. The effects of an FMDV outbreak can have significant financial repercussions, as witnessed in Taiwan in 1997 (up to U.S. $25 billion in losses) and the United Kingdom during 2000–2001 (estimates range in the billions of dollars). One estimate in 2002 suggested that an FMD outbreak in the United States could cost as much as $27 billion.

Transmission of FMDV is usually due to contact with infectious animals or ingestion of contaminated feedstuffs. Hedgehogs have also been implicated in the transmission of FMD in cattle. The causative organism of FMD is a picornavirus (small RNA virus). Like other viruses of this type that can cause human disease (including the common cold

Foot-and-mouth disease can usually only be stopped by culling animals. (Reuters/Corbis) and polio), the viral particle is nonenveloped. Nonenveloped viruses are generally more resistant to environmental stresses, and can remain a source of infection for a considerable time. Although easily killed in acid (pH<6.8–6.5), FMDV is otherwise a very hardy organism. It can survive for long periods in soil and on fomites (infectious objects), and it can be carried in the throat passages of humans.

Though still a subject of some controversy, it has been substantiated that FMDV can be transmissible through the air and can survive being airborne, especially under conditions of high relative humidity. Swine tend to shed many more viral particles than other animals. This may help to explain why the outbreak in Taiwan was so devastating to its swine industry. The similarity between FMDV and swine vesicular disease, also caused by a picornavirus, also makes rapid diagnosis in the field difficult because both diseases share the same clinical manifestations.

Once it has occurred, the proper control of an FMD outbreak is a matter of some dispute, but it generally involves culling animals, setting up perimeters around infected herds, and vaccinating a ring of animals around infected herds. Although vaccines are available for FMD, the efficacy of inoculating herds is limited by the wide number of serotypes of FMDV and the fact that the vaccine may not stop animals from shedding virus. Furthermore, once vaccinated, the animal is thus serologically indistinguishable from other infected animals, and this confounds accurate disease surveillance. From an economic perspective, destroying infected animals and thorough cleaning of contaminated areas are usually the only practical options for controlling the disease.

—Eric A. Croddy

See also: Agroterrorism (Agricultural Biological Warfare)

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FORT DETRICK

Although Fort Detrick, Maryland is today home to several U.S. government agencies including the National Cancer Institute, it is primarily known as the home of the U.S. military's biological weapons research program. As the Department of Defense's lead laboratory for medical biological defense, the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) is an organization designed to develop vaccines, strategies, treatments, training programs, and information packages to counter offensive biological weapons and naturally occurring infectious diseases that require special containment. The Institute is a world-renowned reference laboratory for definitive identification of biological threat agents and diagnosis of the diseases they produce. USAMRIID's staff of 500 includes physicians, microbiologists, pathologists, chemists, veterinarians, molecular biologists, pharmacologists, and physiologists.

Originally a National Guard airfield, Camp Detrick was acquired by the U.S. Army's Chemical Warfare Service in March 1943 as a center for research into biological weapons. Camp Detrick, near Frederick in the foothills of western Maryland's Catoctin Mountains, was ideal for such research because it was isolated, yet close to Washington, D.C., and to the already existing U.S. chemical warfare research establishment at Edgewood Arsenal. The U.S. Army needed a research facility to develop the defensive and offensive biological warfare (BW) capabilities that it lacked on entry into the Second World War. Of particular concern was the need to match Japanese biological warfare capabilities. There were strong rumors at the time that the Japanese had already employed biological weapons in the late 1930s following their invasion of China.

Background

Although much was known about the use of chemical weapons in the early 1940s, given their widespread use in the First World War, little was known about biological agents—the use of living organisms (bacteria and viruses)—as weapons of war. These weapons had the advantage over their chemical counterparts in that not only were they cheaper, but they were also more insidious; they could be used in an attack without the victim knowing that they were being used until it was too late to take defensive measures. The goal of research into biological agents was to manufacture a biological weapon that generated a highly infectious disease against which there was no natural immunity developer (e.g., vaccines) readily available. Research efforts went into ensuring that the biological agents could be produced in bulk and be "weaponized," that is, be able to survive outside the laboratory, be easily spread, and be easily absorbed into the human body. Research was undertaken into offensive biological warfare, creating the weaponized agents, and defensive BW, or developing counters to an enemy's use of biological agents.

During the Second World War, under conditions of great secrecy and under the direction of George Merck (head of the Merck pharmaceutical organization), Camp Detrick housed the testing, development, and production of both anthrax and botulinum munitions. Some of the facility's product was shipped to England later in the war in preparation for any German use of BW. None of these munitions was ever used either in Europe or in the Pacific theater.

After the war, research by the Army's Chemical Corps continued at Camp Detrick. Many new research data were gathered from captured Japanese scientists and military figures who, in the 1930s and 1940s, had participated in notorious BW experiments conducted at Unit 731 in Manchuria. Despite the war crimes committed in the course of that research, scientists from Camp Detrick considered the information from these Japanese BW scientists to be so vital to U.S. national security that they argued for the Japanese scientists to be granted immunity in return for their cooperation.

Although large-scale production of biological agents ceased at Camp Detrick after World War II, it began again in earnest again in 1950 following the outbreak of the Korean War. Against a background of the Korean conflict and a general fear that the new Cold War enemy, the Soviet Union, was developing a substantial BW, or "germ" warfare, capability, Camp Detrick was expanded. An eight-story windowless factory for producing perhaps the most virulent biological agent, anthrax, appeared, as did a structure four stories high to house a huge metal sphere for testing aerosols. Work was conducted not only on lethal agents, but also on incapacitants and hallucinogens. Some 60,000 animals per month were required for the testing of such agents during the 1950s and 1960s.

The increasing scale of the work of the scientists from Fort Detrick (as it was renamed in 1956 to imply its more permanent nature) was not confined to the facility itself. Large-scale experiments were undertaken by personnel from the Maryland facility, involving the release of clouds of what were then presumed to be safe bacteria in cities such as San Francisco, Minneapolis, New York, and even Winnipeg, Canada. These cities were chosen because they approximated in size certain Soviet cities. The scientists wanted to investigate the behavior of bacteria in the atmosphere, looking at how far they spread, how infectious they appeared to be, and how many people they might be expected to kill in a large city. The civic authorities in these test urban environments were told by the Detrick scientists that the "smoke" that appeared above their cities was related to the testing of radar. (Experiments involving biological agents were much too sensitive an issue to reveal to the public or even to local elected officials.) The fact that several mysterious deaths brought about by rare bacteria were recorded at the time of the experiments was only explained years later in the 1970s, when the actual work of the scientists from Detrick was brought to light.

By the end of the 1960s, the work at Fort Detrick had led to the weaponization of such lethal biological agents as anthrax, tularemia, and botulinum and of incapacitating agents such as brucellosis, Q-fever, Venezuelan equine encephalitis, and staphyloccocal enteroxin. These incapacitants were considered to be more humane than lethal agents and could be used, it was hoped, against targets where there might be large numbers of noncombatants. The scientists had also produced biological agents to target food supplies. These were designed to destroy crops, and they included cluster bombs containing turkey feathers impregnated with crop disease spores that were to be dropped from aircraft.

Viruses, too, had been engineered into weapons of war. Viruses are less complex than bacteria and often more deadly. Being much smaller, viruses such as Ebola and smallpox can invade the human body more easily than bacteria, and there are fewer treatments against them. Moreover, friendly forces could be immunized against viruses, enabling them to operate in environments where viral weapons were being used. The staff at Detrick also developed drugs for the U.S. Central Intelligence Agency (CIA) for use in interrogations, and they developed quick-acting poisons for assassinations. Gary Powers, the U-2 spy plane pilot shot down over the Soviet Union in 1960, was supposed to commit suicide, if captured, by using a shellfish (saxitoxin) poison produced at Detrick.

Ethical Concerns

In the heyday of Fort Detrick in the 1950s and 1960s, the scientists there were attempting to overcome several difficulties. Perhaps the most fundamental was the fact that it was impossible to target biological weapons; they were indiscriminate. They would kill military and civilian, friend and foe, without distinction. Some discrimination was attempted; research, for instance, went into developing weapons that only worked on certain ethnic groups. But such work was never popular among researchers.

Most researchers at Fort Detrick believed that the end justified the means, that the demands of national security justified their activities. For these scientists, any weapon, no matter how ethically dubious, that could help defeat a mortal enemy was a welcome addition to the arsenal of democracy. Moreover, there was a sense that whatever research was being conducted in the United States was being more than matched behind the Iron Curtain. The United States had to keep up, they felt.

Ethics, of course, made testing on human subjects difficult. It was vital, though, that such testing be carried out. Fortunately for the scientists at Detrick, some 2,000 men volunteered their services during the period from 1954 to 1973. These were servicemen, mostly Seventh-Day Adventists, who, rather than serve in combat roles (they were conscientious objectors), agreed to act as test subjects. Although subjected to various tests and often becoming ill, none of the servicemen actually died. Their assistance was useful in establishing the effect of individual agents, in developing protective clothing, in proving that certain antibiotics worked against such agents as Q-fever and tularemia, and in demonstrating that the vaccines designed for troops were effective. Although none of these volunteer servicemen died, three employees died in accidents at Fort Detrick over the years: two were killed by anthrax and one by Venezuelan equine encephalitis. Several hundred more have also become ill through accidents and carelessness, although no fatalities have occurred at the facility since the 1960s.

The End of U.S. Biological Weapons Research

After a series of accidents at U.S. military chemical and biological warfare installations and amid a general Vietnam-era disquiet over the role of the military, the U.S. public became more alarmed about the activities undertaken at Fort Detrick and other chemical and biological weapons facilities. Biological agents came to be perceived as doomsday weapons that had no place in the arsenals of civilized states. In 1969, President Richard M. Nixon, responding to the mood and speaking at Fort Detrick, announced that the United States would give up its BW program and destroy existing weapons stocks.

Scientists at Fort Detrick accordingly halted research into offensive biological weapons and destroyed large stocks of stored agents. Small amounts were retained so that testing work could continue, but this work could only be defensive in nature and had to be geared to developing protection, including vaccines, against biological agents. Nixon's initiative led to the Biological and Toxin Weapons Convention of 1972, which outlawed the storage of significant amounts of biological agents by any state. In the aftermath of Nixon's announcement, many workers left Fort Detrick, and the facility was downsized. In 1971, it was renamed the U.S. Biological Defense Research Laboratory and officially handed over to the civilian National Cancer Institute, which was one of a number of new civilian tenants at the base. Part of the camp, however, continued to function as a secure facility housing the USAMRIID.

Fort Detrick scientists have contributed to the treatment of various diseases. Researchers at Fort Detrick have produced vaccines, toxoids (toxin-based vaccines), and antibacterial and antiviral drugs, and they have conducted groundbreaking work in bacterial genetics. Fort Detrick, in the early part of the twenty-first century, remains a valuable resource in terms of developing protective measures against bioterrorism. Nevertheless, Fort Detrick remains controversial. The anthrax letter attacks that followed the September 11 atrocity in 2001 actually employed a strain of anthrax manufactured at Fort Detrick.

—*Rod Thornton*

See also: Bioterrorism; United States Chemical and Biological Weapons Programs; World War II: Biological Weapons

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FUEL-AIR EXPLOSIVE (FAE)

The basic operating principle of a thermobaric or fuel-air explosive (FAE) is analogous to a dust cloud explosion, similar to those that occasionally occur in coal mines or grain silos. In the latter case, fine particles of grain dust in the air can suddenly ignite with a spark, setting off a huge conflagration in a chain-like reaction. Unlike a dust cloud explosion, however, most FAE munitions employ a volatile liquid such as ethylene oxide. An FAE generally consists of a fuel container and two separate explosive charges. At a predetermined altitude, the initial explosive charge ruptures the fuel container, diffusing the fuel, which then mixes with air, creating a vapor cloud. The second explosive charge ignites the vapor cloud, creating a massive explosion accompanied by an enormous shock wave and intense heat. The explosion can generate temperatures ranging as high as 2,500° to 3,000° Celsius. The shock wave can travel at speeds of more than 9,800 feet per second, creating overpressures of 427 pounds per square inch at the center of the explosion, flattening nearby structures. Anyone caught within the immediate blast area would be crushed by the intense pressure. Even those along the blast's fringes are likely to suffer serious internal injuries caused by the subsequent vacuum created by the shock wave. For this reason, the Russian military sometimes refers to FAEs as vacuum bombs. Both U.S. and Russian military analysts have compared the effect of an FAE to that of a low-yield nuclear weapon. Additionally, the psychological effect of such a weapon is significant.

FAEs were initially developed by the United States for use in Vietnam. U.S. forces used them to clear landing strips and to destroy North Vietnamese tunnel complexes. Prompted by the U.S. program, the Soviet Union developed its own FAEs and may even have employed some of its earliest versions against the Chinese military during a border conflict in 1969. The Soviet military did use FAEs against entrenched mujahideen (Afghan and Arab resistance fighters) positions during its invasion and subsequent occupation of Afghanistan. Since that time, the Russian military has used FAEs on several occasions during military operations in Chechnya. From 1994 to 1996, Russian troops regularly used FAEs on entrenched Chechen separatist positions in the mountains outside of the city of Grozny. When the conflict resumed in 1999, the Russian military employed limited numbers of FAEs on separatist-controlled villages near Dagestan.

Later, when Russian conventional arms once again failed to dislodge Chechen separatists from their fortified mountain positions near Grozny, the Russian government again authorized the use of FAEs. Although both FAEs and chemical weapons were initially considered for use against the Chechens, the use of chemical weapons was ruled out, perhaps due to concern that such an action would violate the Chemical Weapons Convention. The use of FAEs is not limited by either international law or arms control agreements. Recently, some man-portable systems produced by the Russian military have been sold to the Chinese People's Liberation Army. These disposable, shoulder-mounted devices fire a self-propelled shell containing ethylene oxide. Its effects—according to the manufacturer—are equivalent to those of a 122-millimeter howitzer shell.

Throughout the 1970s and 1980s, U.S. development of FAEs was primarily concentrated at the Naval Weapons Center in China Lake, California. FAEs developed at the China Lake facility proved their value in Operation Desert Storm, where they overwhelmed entrenched Iraqi forces and cleared minefields in preparation for the allied ground attack. Although FAEs are effective against any "soft target," such as personnel and light structures, they have proven to be particularly useful against minefields, bunkers, and caves.

Press reports during Operation Desert Storm often mistakenly identified FAEs as Daisy Cutters. In fact, the BLU-82B Daisy Cutter is not an FAE, but rather a 15,000-pound conventional explosive that includes both the agent and oxidizer. By comparison, FAEs weigh between 500 and 2,000 pounds and are oxidized by exposure to the atmosphere. Due to the difficulty of maintaining the proper fuel-to-air mixture, it would be highly problematic to develop an FAE as large as a Daisy Cutter

Despite their proven battlefield utility, ten years after the end of Operation Desert Storm, the U.S. military had decommissioned all but a few hundred of its FAEs, probably due to their uncertain roles in future conflicts. This put the military in an unwelcome position as it prepared for operations in Afghanistan in late 2001: It faced a severe shortage of a weapon designed for use against precisely the targets that it now expected to encounter in Afghanistan. To resolve this situation, on October 11, 2001, the Defense Threat Reduction Agency (DTRA) began a 60-day effort to develop a new weapon specifically designed to defeat underground targets. The development team included members from the Air Force, the Department of Energy, the Naval Surface Warfare Center at Indian Head, Maryland, and private industry.

At the end of 67 days, the team unveiled the BLU 118/B "Thermobaric Weapon." The term *thermobaric* comes from the Greek words for heat (*therme*) and pressure (*baros*). The BLU 118/B has a fuel-air explosive warhead fitted onto the body of a BLU 109 Penetrator that can punch through hardened concrete structures. As such, the BLU 118/B possesses the penetrating ability of a BLU 109 Penetrator and the destructive capability of a fuel-air explosive. On December 14, 2001, the BLU 118/B successfully completed both static and flight tests conducted at the Nevada test site. These tests included fitting a BLU 118/B warhead onto a laser-guided weapon and "skipping" it into the mouth of a tunnel to simulate the targets that the DOD (Department of Defense) anticipated using it against in Afghanistan.

On December 21, 2001, Edward C. Aldridge, Undersecretary of Defense for Acquisition, Technology, and Logistics, announced that the BLU 118/B had completed testing and was being deployed to Afghanistan to support Operation Enduring Freedom. Less than 3 months later, on March 3, 2002, the BLU 118/B was used for the first time on an al-Qaeda cave complex located in the Gardez region of Afghanistan. In less than 5 months, the DTRA team had been able to develop, produce, test, and deploy a weapon system critical to U.S. success in Afghanistan.

Since the attacks on September 11, 2001, the United States has perceived a growing threat from rogue states and international terrorist organizations that are attempting to acquire nuclear, biological, and chemical (NBC) weapons. Given the capabilities of current U.S. space-based reconnaissance satellites, clandestine NBC development and processing facilities are likely to be located underground. The U.S. Air Force and Navy are currently attempting to develop a conventional weapon capable of destroying a potential underground NBC target while limiting potential agent dispersal. The new BLU 118/B, with its ability to penetrate hardened structures and to produce significant amounts of heat, is a potentially significant step toward realizing this objective with a nonnuclear weapon.

—William S. Clark

See also: Aerosol

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G

GAS GANGRENE

Clostridium perfringens (C. perfringens) is a common bacteria associated with three distinct disease syndromes: gas gangrene, enteritis necroticans, and clostridium food poisoning. Clostridium bacteria produce at least twenty different toxins; the toxins produced by the clostridium bacteria are what cause disease in its victims. Although weaponization of *C. perfringens* would be a difficult endeavor, it is not impossible, and it therefore merits consideration as a possible biological warfare agent.

History and Background

Louis Pasteur, in 1861, identified the first clostridial species, *Clostridium butyricum.* Later, other scientists isolated a gram-positive anaerobic (see below) bacterium from gangrenous wounds. This organism, originally known as *Bacillus aerogenes capsulatus* (later *Bacillus perfringens,* then *Clostridium welchii,* and now *C. perfringens*), gained recognition for its appearance in battlefield wounds.

Despite the inherent difficulties associated with weaponization of *C. perfringens*—notably challenging would be the isolation of toxins or the use of the whole cell—the gas gangrene-causing bacterium has appeal as a biological weapon for its range as either a toxic or bacteriological weapon and its ability to exploit the condition of existing battlefield wounds. Although the toxins are lethal in and of themselves in an aerosolized form, the use of the *C. perfringens* spore bacteria in a shrapnel munition—either as a slurry or as a refined powder—would aggravate penetrating wounds and create a potentially fatal condition among its victims, at the very least removing them from the theater of combat.

At least three countries investigated the weaponization of *C. perfringens:* Japan, South Africa, and Iraq. Information on the measure of success each of these countries had in weaponizing *C. perfringens* is scant. It does appear that their efforts at the weaponization process were forestalled.

Technical Details

C. perfringens is an anaerobic (i.e., it is unable to grow in the presence of free oxygen) spore-forming rod bacterium. Commonly found in the environment and the intestines of humans and animals, its spores persist in soil, sediments, and areas subject to human or animal fecal pollution. Though the clostridium bacteria produce at least 20 types of toxins, four are of particular BW interest because they can cause potentially fatal syndromes: alpha, beta, epsilon, and iota. These toxins, one of the main causes of gas gangrene, can cause tissue death, destruction of blood, decrease in circulation, and leaking of the blood vessels.

Called gas gangrene because of the bubbles seen in the wounds (a result of bacteria-produced hydrogen gas), gas gangrene typically develops in deep crushing or penetrating wounds that have been cleaned improperly. Disease onset typically begins one week after the introduction of bacteria to the wound. The main initial symptom of gas gangrene—or "wet" gangrene—is pain at the site of the wound, which becomes progressively worse. Untreated, gas gangrene can be fatal; progression from symptomatic disease onset to death can occur within 2 days. The main treatments for gas gangrene are antibiotics and surgical removal of affected tissue. When the *C. perfringens* toxins are inhaled as an aerosol, severe lung damage results, leading to pulmonary edema and respiratory failure. When absorbed by the body, red blood cell destruction and liver damage occur.

—Jennifer Lasecki

See also: Iraq: Chemical and Biological Weapons Programs

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GB

See Sarin

GENEVA PROTOCOL

The "Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous, or Other Gases and of Bacteriological Methods of Warfare" was signed on June 17, 1925 and entered into force on February 8, 1928. Early signatories included the United States, Germany, Iraq, and Russia. Japan signed in 1970, and the United States formally ratified the Protocol in 1975. (Signing a treaty basically means that a state is willing to abide by its precepts, but its government will have to ratify it through a formal process before it becomes law.) The 1925 Geneva Protocol, also known as the Gas Protocol, was meant to codify an international opprobrium on using "asphyxiating, poisonous or other gases, and of bacteriological methods of warfare." Although the Geneva Protocol attempted to prohibit (with certain and significant exceptions) the use of chemical and biological weaponry, the historical record shows the agreement to have been largely ineffectual. Although the Chemical Weapons Convention (CWC) does not concern itself with biological weapons, since coming into force in 1997 the CWC has superseded the 1925 Geneva Protocol.

Background

Interrupted by World War I—and the advent of modern chemical warfare—the 1925 Geneva Protocol was really the culmination of previous attempts to outlaw the use of toxic chemicals on the battlefield. One of the first meetings of the major powers to address the use of poisons in war was the Hague Peace Conference of 1899, sponsored by Tsarist Russia. In line with what had been previously raised in the Brussels Declaration of 1864 that had prohibited poisons or poisoned gases meant to cause unnecessary suffering in war, three declarations were made at the Hague Conference of 1899: Reflecting the times and new technology, one declaration prohibited the use of projectiles from balloons. Another required that the treaty's parties agree to end the use of "dum-dum" or expanding bullets in war. Finally, the third prohibition concerned itself with those projectiles "the sole object of which is diffusion of asphyxiating or deleterious gasses." The American delegate, Admiral Alfred T. Mahan, was certainly not impressed, however, when it came to the latter prohibition of asphyxiating or deleterious gasses: "It is illogical and not demonstrably humane to be tender about asphyxiating men with gas, when all are prepared to admit that it is allowable to blow the bottom out of an ironclad at midnight, throwing four or five hundred men into the sea to be choked by the water, with scarcely the remotest chance to escape" (Fries and West, p. 6).

Germany signed and ratified the Hague agreement in September 1900, but the United States elected not to sign the Hague declaration. Those countries that did accede to the regime by signing the document pledged to "Abstain from the use of *projectiles the sole object* of which is the diffusion of asphyxiating or deleterious gases" (Hague Declaration, emphasis added). As Augustin Prentiss noted in his treatise on chemical warfare, at the time of the Hague Conference, such projectiles had not yet been perfected for use in battle. Later, this technicality would be invoked during World War I, some arguing that the use of static canisters to release poison gas was exempt as they were not "projectiles."

Despite earlier pessimism expressed by President William McKinley and Admiral Mahan, President Theodore Roosevelt put his imprimatur on a second round of talks to further discuss a prohibition of chemical weapons at the Hague Convention in 1907. It was concluded as Article XXIII of Hague Convention IV, regarding laws and customs of war on land, "in addition to the prohibitions provided by special conventions, it is expressly forbidden to employ poisons or poisonous weapons" (Hague Declaration, 1907).

PROTOCOL FOR THE PROHIBITION OF THE USE IN WAR OF ASPHYXIATING, POISONOUS, OR OTHER GASES, AND OF BACTERIOLOGICAL METHODS OF WARFARE

Opened for signature: 17 June 1925, entered into force: 8 February 1928

The undersigned Plenipotentiaries, in the name of their respective governments:

Whereas the use in war of asphyxiating, poisonous or other gases, and of all analogous liquids, materials or devices, has been justly condemned by the general opinion of the civilised world; and

Whereas the prohibition of such use has been declared in Treaties to which the majority of Powers of the world are Parties; and

To the end that this prohibition shall be universally accepted as a part of International Law, binding alike the conscience and the practice of nations;

Declare:

That the High Contracting Parties, so far as they are not already Parties to Treaties prohibiting such use, accept this prohibition, agree to extend this prohibition to the use of bacteriological methods of warfare and agree to be bound as between themselves according to the terms of this declaration.

The High Contracting Parties will exert every effort to induce other States to accede to the present Protocol. Such accession will be notified to the Government of the French Republic, and by the latter to all signatories and acceding Powers, and will take effect on the date of the notification by the Government of the French Republic.

The present Protocol, of which the English and French texts are both authentic, shall be ratified as soon as possible. It shall bear to-day's date.

The ratifications of the present Protocol shall be addressed to the Government of the French Republic, which will at once notify the deposit of such ratification to each of the signatory and acceding Powers.

The instruments of ratification of and accession to the present Protocol will remain deposited in the archives of the Government of the French Republic.

The present Protocol will come into force for each signatory Power as from the date of deposit of its ratification, and, from that moment, each Power will be bound as regards other Powers which have already deposited their ratifications.

In witness whereof the Plenipotentiaries have signed the present Protocol.

Done at Geneva in a single copy, the seventeenth day of June, One Thousand Nine Hundred and Twenty-Five.

For the United States military at the time, rules against using poisons in battles were already in place. General Order No. 100 by the War Department in April 1863 had laid down the following: “The use of poison in any manner, be it to poison wells, or food, or arms, is wholly excluded from modern warfare” (Smart, p. 13). Following the Hague Convention of 1907, the United States published its own regulation in War Department Document No. 468 that put more detail and emphasis into the agreement, adding that biological warfare was implied as well: “This prohibition extends to the use of means calculated to spread contagious diseases, and includes the deliberate contamination of sources of water by throwing into same dead animals and all poisonous substances of any kind” (Prentiss, p. 687).

The Hague Convention had attempted to outlaw the use of projectiles carrying toxic chemicals. What could not have been foreseen were the massive clouds of chlorine gas that augured in modern CW during World War I. In fact, not long after the chlorine gas attack at Ypres, Belgium, in 1915, a German newspaper explained that “the basic idea of the Hague agreements was to prevent unnecessary cruelty and unnecessary killing when milder methods of putting the enemy out of action suffice and are possible. From this standpoint the letting loose of smoke clouds, which, in a gentle wind, move quite slowly toward the enemy, is not only permissible by international law, but is an extraordinarily mild method of war” (SIPRI, p. 53).

Following the cataclysm that was World War I and the unpleasant memory of chemical warfare, polling data in the United States showed that a large percentage of Americans wanted to abolish chemical weapons. At the Conference for the Limitation of Naval Armament (1921–1922, later referred to as the Washington Arms Conference), the American delegation, chaired by General John J. "Blackjack" Pershing, argued for the prohibition of chemical weapons. Still, the delegation noted "that there are arguments in favor of the use of gas which ought to be considered. The proportion of deaths from their use, *when not of toxic character,* is much less than from the use of other weapons of warfare" (Ewing, p. 69). Nonetheless, the U.S. Senate unanimously ratified the treaty signed at the Washington Conference, with only minor objections made during floor debates. But the Washington Arms Conference of 1922 never went into force due to objections by France, a key player in the Conference.

In 1925, the League of Nations called for a meeting that was originally called the International Conference on Supervision of the International Trade in Arms and Ammunition and Implements of War. It was in this conference on arms regulation that the United States suggested adding proposals to ban chemical warfare, in order to lessen "the horrors of war and ameliorating the sufferings of humanity incident thereto" (Prentiss, p. 692). The U.S. State Department wanted an international approval of a ban on the export of war gases. France made the suggestion to ban the use of such chemicals, and Poland recommended that the agreement further prohibit bacteriological warfare as well. Thus came into being the 1925 Geneva Protocol.

The Geneva Protocol began with considerable vision and promise. Though farsighted in the sense that it banned both chemical and biological forms of combat, the Protocol also contained key conditions and exemptions that made it an ineffective treaty. For although the agreement prohibited the *use* of such weapons in battle, it did not expressly prohibit the use of CW agents against nonratifying parties, the retaliatory use of chemical weapons (making the Protocol a de facto "no first use" agreement), or the use of chemical weapons in civil conflicts within a country's own borders. Perhaps the most glaring flaw in the 1925 Geneva Protocol was that it did not prohibit research, production, or stockpiling of chemical or biological weapons, and some countries additionally reserved the right to retaliate using these weapons. Anticipating the proliferation concerns that would still remain 75 years later, the originator of the initiative to ban biological weapons in the 1925 Geneva Protocol, Polish general Casmir Sosnkowski, warned that the bacteriological weapon "can be manufactured more easily, more cheaply and with absolute secrecy" (Geisler and Moon, p. 66).

A campaign led by U.S. general Amos Fries, chief of the Army Chemical Warfare Service, argued that a vote for ratification of the 1925 protocol by the U.S. Senate would mean a decline in military readiness. The American Chemical Society was also against the agreement. Partly as a result of such lobbying, the United States did not ratify the Geneva Protocol until 50 years later. Other countries that did not ratify the Protocol in 1925 included Argentina, Brazil, Czechoslovakia, and Japan, but thirty-nine countries ratified the protocol before World War II. Regarding the Geneva Protocol and its lack of commitments from the global community, in 1937, Prentiss warned that "its apathetic reception by various governments has tended to defeat the purpose it was expected to serve" (Prentiss, p. 693).

With the 1993 Chemical Weapons Convention now in force, the Geneva Protocol is mostly only relevant today in its prohibition of biological warfare. However, its glaring loopholes (as presciently noted by General Sosnkowski) remain. As of 2004, movement toward a global treaty to enforce the toothless Biological and Toxin Weapons Convention has stalled, awaiting some initiative to achieve consensus among its parties.

—Eric A. Croddy

See also: Biological and Toxin Weapons Convention (BTWC); Chemical Weapons Convention (CWC); Hague Convention

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GF

See Cyclosarin

GLANDERS (*BURKHOLDERIA MALLEI*)

Burkholderia mallei is the bacterium that causes the disease glanders. It has been researched, developed, and utilized as a biological weapon in wartime by national bioweapons programs.

Historical Background

Glanders was once the most feared and economically important fatal contagious disease of equids (horses, asses, and mules). It was eradicated by 1920 in western Europe and North America through the identification and destruction of infected animals. Before this, humans occasionally contracted glanders, which was often fatal. Autopsy material from equids that died of glanders and laboratory cultures of the bacteria were extremely dangerous to handle. Before it was eradicated, glanders was the most common cause of fatal laboratory infections among bacteriologists.

During World War I, the German military attempted to use glanders bacteria in a worldwide effort to infect the horses of the Allied powers and to disrupt shipments of horses and mules from neutral countries to the Allies. Saboteurs using glanders bacteria cultures were active in France, the United States, Romania, Spain, and Latin America. Despite these extensive efforts, the effects of this campaign were minimal in western Europe and North America. There was a single suspicious glanders outbreak that occurred in Britain in a military stable, but glanders cases among horses in combat units in France were few and easily contained. No significant disruption of the supply of horses occurred on the western front. Large outbreaks of glanders did occur in Russia and Portugal, but as glanders was endemic in these areas, it is unknown whether these outbreaks were natural or the result of BW sabotage.

During World War II, the Imperial Japanese Army's biological weapons program developed glanders as a major agent for both antianimal and antihuman biological warfare. In undertaking this program, the Japanese committed atrocities by intentionally causing fatal human glanders infections at their research facilities. Glanders bacteria were produced in industrial quantities and were employed with other biological agents against Chinese civilians, Chinese troops, and military draft animals during a campaign in 1942 in Zhejiang Province. This campaign resulted in hundreds of civilian deaths from glanders among the local Chinese population, as well as losses of military equids.

After erroneous reports of continued German interest in glanders as a BW weapon, the U.S. biological weapons program investigated the possible use of glanders as a weapon during World War II. The program inadvertently caused at least seven laboratory infections among workers, and investigation into the offensive use of glanders was stopped at the end of the war.

Technical Details

Glanders can be spread by inhalation, by inoculation, by ingestion, or by direct contamination of the nose and mouth. The signs and symptoms of glanders in humans vary. Rapidly progressive cases show fever and septic collapse, often with a rash similar to smallpox developing on the day prior to death. Direct exposure of the face often causes deforming ulcers in the nose and mouth. Slowly progressive and chronic cases develop persistent fever with multifocal pulmonary and liver lesions. Chronic cases often develop soft-tissue swellings, notably on the arms and legs, that break down into draining sores.

Under natural conditions, water troughs that were contaminated by nasal secretions transmitted glanders from horse to horse. Humans were infected by contact with this water or with contaminated bits and harnesses. The Japanese caused thousands of cases of human and equine glanders by contaminating rural Chinese water supplies with glanders. Fortunately, standard chlorination and other modern water purifying processes very easily kill glanders bacteria. There is, however, the potential for glanders to be developed into an airborne biological weapon.

Because glanders has been essentially extinct in Europe and North America for more than 50 years, and because it apparently does not cause human disease in areas where it is still endemic in equids, current hospital automated bacteriological laboratory procedures fail to identify it accurately in humans. Likewise, descriptions of human glanders usually do not appear in current, standard medical textbooks. This presents a major problem in the surveillance of glanders as a potential bioweapon.

The glanders bacterium currently has the name *Burkholderia mallei.* Its genus name, however, has often changed. It is closely related to the bacterium that produces melioidosis (*Burkholderia pseudomallei*). Glanders is classified as a Category B threat agent by the U.S. Centers for Disease Control and Prevention (CDC), a category that also includes less lethal BW agents such as Q-fever and Brucellosis. The U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) has begun to investigate it again, and a laboratory infection involving glanders occurred in 2000.

In its natural state, glanders apparently requires large, crowded urban or military populations of horses to maintain the dangerous, highly virulent strains so common before the twentieth century. With the advent of modern mechanized transport, these sorts of dense animal populations have generally ceased to exist. The remaining natural reservoirs of glanders in Asia consist of much-attenuated strains that seldom cause death in horses and that apparently do not infect humans. No human case of naturally occurring glanders has been reported in the United States since 1939.

Only a few specialized veterinary laboratories can claim legitimate civilian veterinary uses for even the highly attenuated laboratory strains of this organism used to produce diagnostic reagents. Glanders has ceased to circulate among horses in Europe, the Americas, and Oceania. It is no longer an important economic disease of horses even in areas where it remains endemic, including parts of Turkey, Iraq, Iran, Afghanistan, India, and Pakistan.

The fact that glanders is highly dangerous to handle, even in facilities as sophisticated as USAMRIID, means that accidental infections are likely to occur if it is handled in improvised or amateur biological weapons facilities. Even a single case of human glanders should act as a very important "sentinel event" for identifying clandestine bioweapons activities or an intentional BW release. If the low-virulence strains now circulating are modified to develop increased virulence, glanders could become the basis of a biological weapon.

—*Martin Furmanski*

See also: Agroterrorism (Agricultural Biological Warfare); Bioterrorism; World War I

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GRUINARD ISLAND

Gruinard Island is an island off the northwest coast of Scotland that was used as a British biological weapons testing ground during World War II. Gruinard (pronounced "grin-yard") is a 522-acre island measuring 1.24 miles by 0.62 miles, situated one-half mile off Scotland's coast in Gruinard Bay. Although a handful of people lived on Gruinard at the turn of the century, there were no human inhabitants left by the 1930s. Early in World War II, based on intelligence concerning Axis biological research, the British War Cabinet decided to investigate ways to retaliate should the Germans employ biological warfare. Initial research on *Bacillus anthracis* (the causative agent of anthrax) had been conducted with American and Canadian help at Porton Down (U.K.), but by the summer of 1942, the British government sought a site for open-air trials to see whether *B. anthracis* spores would remain infective after explosive dispersal. Gruinard, being remote yet close to a large Allied military base at Loch Ewe, was chosen, requisitioned, and given the code name X Base.

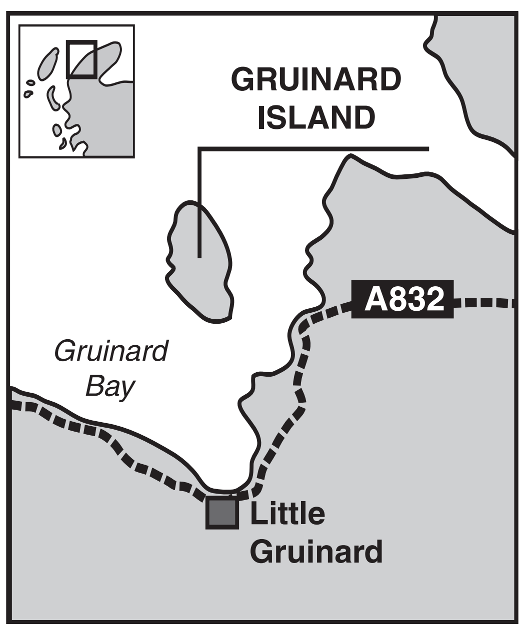
Under the project leader, microbiologist Paul Fildes, researchers first used an airplane to drop a 30-pound bomb filled with a slurry containing spores of *B. anthracis.* Subsequent trials included a variety of explosive devices suspended from wooden scaffolding 6 feet above the ground.

Gruinard Island—the site of World War II–era anthrax weapons testing—has since been returned to the original owners. (Topham/The Image Works)

These devices were detonated electrically near lines of sheep positioned at various distances downwind from the explosions. Afterwards, the sheep were transferred to an observation paddock. Dozens died, proving the efficacy of an anthrax bomb.

An unintentional outbreak of anthrax among livestock on the mainland in 1943 was apparently caused by a contaminated sheep carcass from Gruinard that had been unearthed by a storm and had floated to the mainland. No human fatalities were reported, and the outbreak was contained. Concerned about public safety, however, the British military ceased testing on Gruinard in August 1943 and declared the island off limits. Contrary to government expectations, samples taken in 1943, 1944, and 1946 indicated that the *B. anthracis* spores on the island remained viable, so in 1946 the United Kingdom bought the entire island of Gruinard, promising to return it to the original owners for £500 (about one pound Sterling per acre) when it was deemed safe.

Gruinard Island



Annual inspections between 1946 and 1968 revealed the continuing virulence of spores, and sampling was mostly discontinued until 1979, when responsibility for Gruinard was assumed by the Chemical Defense Establishment (CDE) at Porton Down. A comprehensive survey was undertaken and an improved assay technique was used that could detect three spores per gram of soil. This revealed that, despite the release of 10^{14} spores, only approximately 3 acres around the test site (less than 1 percent of the island's surface) were found to have been contaminated, with spores mostly found within the top three inches of soil. This finding meant that decontamination of Gruinard was feasible.

An interesting episode occurred in October 1981, when an ecologically motivated group called Dark Harvest placed a bucket with contaminated soil from Gruinard at the CDE in protest of perceived government indifference to the island's contamination.

In 1985, the Ministry of Defense initiated the creation of an Independent Advisory Group (IAG) for Gruinard Island, made up of eminent scientists to review the CDE's findings and decontamination proposal. In 1986, a private contractor was commissioned to decontaminate a total area of just over 10 acres on Gruinard. After spraying a herbicide and burning away the undergrowth, a system consisting of 30 miles of irrigation tubing was used to soak the ground with 280 tons of formaldehyde diluted in 2,000 tons of seawater in amounts of 50 liters per square meter. Topsoil was also removed in sealed containers and decontaminated. After retreating a few areas in July 1987, no viable spores of *B. anthracis* were detected on the island. As an extra precaution, forty sheep belonging to a local farmer were allowed to graze on the island from May to October 1987 and were closely monitored.

In its final 1988 report, the IAG concluded that Gruinard Island could be returned to civilian use, and, in May 1990, the island was sold back to the heirs of its original owners. Gruinard Island remained only an interesting historical footnote until the anthrax attacks in November 2001 in the United States, when reporters flocked to Gruinard to recall Britain's brief foray into biological weapons.

> *"For air, stone, and the equilibrium of understanding, welcome back Gruinard"*
>
> —inscription on a plaque commemorating Gruinard's decontamination

—Gary Ackerman

See also: Anthrax; Decontamination; United Kingdom: Chemical and Biological Weapons Programs

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G-SERIES NERVE AGENTS

The NATO coded G-series ("G" as in Germany) nerve agents include the first toxic organophosphates produced for chemical warfare by the German military during World War II, starting with tabun (GA), sarin (GB), soman (GD), cyclosarin (GF), and some analogues synthesized many years after World War II (such as GV). There is no nerve agent referred to as "GC," probably because this had already been used in the U.S. military to code for gonorrhea. The more toxic of the G-series include GB and GD, but are less toxic than V-series agents (e.g., VX).

—Eric A. Croddy

See also: Cyclosarin (GF); Nerve Agents; Sarin; Soman; Tabun

GULF WAR: CHEMICAL AND BIOLOGICAL WEAPONS

When a U.S.-sponsored coalition attempted to drive Iraqi forces from Kuwait in early 1991, there were fears that Iraq would use a weapon of mass destruction. This proved not to be the case, but for coalition leaders, the threat that Iraq might use a chemical or biological weapon was very real. Iraq had shown during the Iran-Iraq War that it had chemical warfare capability and was willing to use it against its adversary in the war and against domestic opposition groups.

Even before his invasion of Kuwait, Saddam Hussein had threatened to "rain down fire" on Israel, which a number of commentators interpreted as a threat to employ chemical weapons. Once the invasion of Kuwait had taken place, Iraq threatened to use such weapons against coalition forces and Israel. Hussein was attempting to establish a deterrence relationship with the coalition by suggesting that any attack on Iraq (including Kuwait, which Iraq claimed was its lost "nineteenth province") would justify retaliation with chemical weapons. By threatening to attack Israel, Hussein promised to spread any Gulf conflict throughout the Middle East and turn Arab public opinion to the Iraqi cause by somehow linking the seizure of Kuwait to the Palestinian-Israeli dispute. To reinforce this threat, Iraq reportedly established decontamination sites in the Kuwaiti theater of operations.

Prewar coalition assessments credited Iraq with a formidable arsenal of chemical weapons, including mustard, two nerve agents (tabun and sarin), and other compounds that were in development or production. In addition, the Iraqi military had experience in actually employing chemical weapons in combat. Little was known, however, about Iraq's biological weapons program. After the war, it was discovered that Iraq had accelerated its production of anthrax and botulinum toxin prior to Desert Storm. Rolf Ekeus, the Executive Chairman of the UN Special Commission (UNSCOM), was subsequently informed that authority had been delegated to local Iraqi commanders to use chemical and biological weapons in response to a massive coalition attack on Baghdad.

During the war, Coalition air strikes destroyed or damaged most of Iraq's chemical warfare production and filling capabilities, but stocks that had been relocated before the war were assumed to have survived. Subsequent UN inspections of Iraq revealed a significant chemical weapons infrastructure.

Reasons for Nonuse

Why did the Iraqi regime fail to use its chemical and biological arsenal during the Gulf War? Iraq had a variety of proven delivery mechanisms including aerial bombs, aerosol sprays, artillery shells, ground-to-ground and air-to-ground rockets, chemical warfare mines, and Scud missiles. Why it chose not to use this arsenal is not entirely clear. The weapons might have been viewed by the Iraqi regime as political and psychological weapons; once the war began and Iraq's bluff had been called, these weapons might have been held in reserve to guarantee the survival of the Iraqi regime.

Hussein also may have been deterred by the threat of U.S. dominance in the event of escalation of the conflict: if Iraq employed chemical weapons, it might have been subjected to devastating U.S. conventional or even nuclear retaliation. (In a final meeting before the outbreak of the war, U.S. Secretary of State James Baker had handed Iraqi Foreign Minister Tariq Aziz a letter from President George H. W. Bush, which was purported to carry a warning about Iraqi use of weapons of mass destruction.) In any case, it is doubtful whether Iraqi use of chemical weapons would have significantly altered the outcome of the war. After the war, no evidence was discovered that suggested that these weapons were even deployed with the fielded Iraq forces.

—Andrew M. Dorman

See also: Gulf War Syndrome; Iraq: Chemical and Biological Weapons Programs; United Nations Monitoring, Verification, and Inspection Commission (UNMOVIC)

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GULF WAR SYNDROME

As the name suggests, Gulf War Syndrome refers to a clinical syndrome experienced by a cohort of United States and other Coalition personnel who served during the 1990–1991 Gulf War against Iraq. Gulf War syndrome (GWS) is a poorly defined condition generally described as a constellation of fatigue, mood-cognition problems, and musculoskeletal pain. No causative agent—by itself or in combination with environmental pollutants such as chemical warfare (CW) toxins or biological pathogens—has yet been identified as the cause of the mysterious ailment. Following the overthrow of Saddam Hussein's government in April 2003, similar complaints that closely resemble that of GWS have surfaced among combatants participating in Operation Iraqi Freedom.

Despite exhaustive (and, in some instances, redundant) clinical and epidemiological studies, an organic cause of GWS has not been found. For example, nearly a decade following the first Gulf War (1990–1991), British researchers studied 1,000 self-selected members of a Gulf War cohort who suffered from GWS. They reported that "Fatigue, joint and muscle aches and pains, and affective symptoms (such as mood swings and anxiety) were the most common symptoms. Many other symptoms occurred, but no clinically consistent pattern existed to suggest a common underlying disease process" (Coker et al., 1999, p. 294). Nor do follow-up studies show any higher incidence of birth defects among the progeny of Gulf War veterans than in control groups.

Assuming that GWS can be clinically defined as an illness, a number of candidate agents have been offered as its cause. These include purported exposure to chemicals including chemical warfare (CW) agents, anthrax vaccine, botulinum toxoid, and other biological pathogens. As far as CW agents are concerned, there is one publicly known incident in which a U.S. soldier suffered injury following the Gulf War in 1991. His exposure to sulfur mustard led to minor burns while securing one of many Iraqi ammunition depots. After the war, U.S. military personnel destroyed the Iraqi ammunition cache at Khamisiyah, which later turned out to have contained unknown quantities of nerve agent. Thus, possible exposure to nerve agents was studied as a potential cause of GWS among those veterans in the region. No evidence has been found to show, however, that any coalition forces were exposed to toxic concentrations of nerve agent at Khamisiyah.

Other researchers have suggested that long-term effects of toxic compounds, particularly the organophosphate nerve agents, could cause neural deficits even at low concentrations. Toxicological studies of soman and sarin before and after the Gulf War, however, do not support this view. Unlike some insecticides and toxic organophosphates used in other contexts, exposure to nerve agent that would cause long-term (or delayed) neuropathy would require very large doses—and probably deadly ones at that.

Another purported cause of GWS is the use of nerve agent antidotes by U.S. soldiers, or more specifically, pretreatment against soman nerve agent exposure. Prior to Operation Desert Storm (1991), U.S. military planners were concerned that Iraq could use CW agents, including soman, a nerve agent that is difficult to treat due to its propensity to "age" the body's enzyme acetylcholinesterase (AChE). In addition to antidotes containing a combination of atropine and oxime to reverse the effects of nerve agents, U.S. personnel were prescribed pyridostigmine bromide (PB), a carbamate compound, in the form of tablets. PB temporarily inhibits a small portion of the body's AChE as a means to protect it from being permanently blocked by soman or perhaps another nerve agent. The doses of PB to be administered were relatively small, but they did cause some discomfort (intestinal gas and urinary urgency) among soldiers who took them. Anecdotal evidence also shows that more than a few soldiers simply decided not to follow this regimen. In any event, some advocacy groups and GWS researchers have suggested that PB tablets, in combination with other factors, could have played a role in postwar illness. These suggestions, however, are not supported by available data.

The use of vaccines to protect against biological warfare (BW) agents has also been suggested as a cause of GWS. Using last-minute approval from the Food and Drug Administration, the U.S. military vaccinated a limited number of personnel (about 8,000) with botulinum toxoid. In 1997, the Presidential Advisory Committee on Gulf War Veterans' Illnesses concluded that the use of botulinum toxoid did not play a role in developing GWS among veterans. In contrast to the small number of botulinum vaccinations, some 150,000 U.S. servicemen were inoculated against anthrax during the time leading up to Desert Storm (1991). Since then, a number of studies have been conducted to determine whether this might have contributed to ailments among Gulf War veterans. Here, too, the Presidential Advisory Committee concluded, "it is unlikely that health effects reported by Gulf War veterans today are the result of exposures to the BT or anthrax vaccines, used alone or in combination" (Presidential Advisory Committee on Gulf War Veterans' Illnesses: Final Report, p. 114).

In 1999, the periodical *Vanity Fair* carried a story that discussed claims by some medical researchers that squalene could be the cause of GWS. An intermediate compound found in cholesterol synthesis, squalene (molecular formula $C_{30}H_{50}$) is found in earwax and shark liver oil, among other sources. Squalene has been used as an adjuvant (a substance that can boost the immune system's response, enhancing the effectiveness of a vaccine) in human trials for possible HIV, herpes simplex virus (HSV-2), cancer therapy, and malaria vaccine research. After some studies found evidence of squalene antibodies in veterans who were complaining of GWS, advocates suggested a possible link, suggesting that squalene had been used as an adjuvant for anthrax vaccinations among U.S. military personnel during the 1991 Gulf War. There is no evidence, however, that squalene was ever used in anthrax vaccinations. Nor has a link between squalene and GWS been demonstrated.

Other chemicals that have been suggested as playing a role in GWS etiology include remnants of depleted uranium (DU) bullets (dense projectiles containing uranium depleted of U235 isotope; used against armor), petroleum smoke, and organophosphate insecticides in combination with mosquito repellent (diethyl toluamide or DEET). As with other claims that GWS was caused by certain types of chemical exposures during the Gulf War conflict(s), these have not been substantiated.

In addition to chemicals having been alleged to cause GWS, microbiological agents such as *Mycoplasma fermentans* have been implicated as a source of illness. No links between this organism and GWS were found in an extensive study performed by the U.S. Armed Forces Institute of Pathology (Lo et al., 2000). Another infectious disease agent, a parasitic organism that causes leishmaniasis (*Leishmania tropica*), a disease typified by skin lesions (Kala-azar), affected at least thirty-two Gulf War veterans, a dozen of whom developed the more serious visceral form.. (The other twenty developed the cutaneous form, also known as the Baghdad boil.) Leishmaniasis in this limited number of individuals, however, did not explain the wider prevalence of reported GWS among veterans.

In 1995, increased political pressure regarding GWS and its purported effect on U.S. Gulf War veterans led President William Clinton to form the Presidential Advisory Committee on Gulf War Veterans' Illnesses. In its 1997 final report, the committee concluded: "although some veterans clearly have service-connected illnesses, current scientific evidence does not support a causal link between the symptoms and illnesses reported today by Gulf War veterans and exposures while in the Gulf region to the following environmental risk factors assessed by the Committee: pesticides, chemical warfare agents, biological warfare agents, vaccines, pyridostigmine bromide, infectious diseases, depleted uranium, oil-well fires and smoke, and petroleum products." The report did suggest, however, that "stress is likely to be an important contributing factor to the broad range of illnesses currently being reported by Gulf War veterans" (Presidential Advisory Committee on Gulf War Veterans' Illnesses: Final Report, p. 114).

If there is an identifiable disease known as GWS, one is drawn after significant research into its origins to the conclusion that its cause is unlikely to be found. There is a possibility that GWS falls into a category of health conditions that have historically followed veterans and their war experiences. Following the U.S. Civil War, for example, the ailment was known as soldier's heart. Among World War I veterans in England, it was called effort syndrome, and U.S. military physicians termed it neurocirculatory asthenia."Many of the symptoms described in these syndromes are not dissimilar from those of GWS.

—*Eric A. Croddy*

See also: Iraq: Chemical and Biological Weapons Programs; Nerve Agents; Pyridostigmine Bromide; Vaccines

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H

HAGUE CONVENTION

This treaty, developed at the First Peace Conference at The Hague, July 29, 1899, entered into force on September 4, 1900. The treaty discussed the most efficacious means of ensuring the benefits of real and durable peace and addressed how to stop the progressive development of armaments, including the prohibition of the employment of poison or poisoned arms in war.

The conference was convened at the invitation of Count Mikhail Nikolayevich Muravyov, the foreign affairs minister of Russia. It was one of a series of conferences intended to ensure a lasting peace among the great powers of Europe, and it followed in the aftermath of the partial successes of the Geneva Convention (1864) and Brussels Declaration (1874). The Hague Convention included many important declarations, the most significant being the Declaration on the Use of Projectiles the Object of Which Is the Diffusion of Asphyxiating or Deleterious Gases.

The asphyxiating gases declaration reached by the twenty-four states at the conference forbade the use of projectiles that are solely intended to diffuse asphyxiating gases, and it also forbade the utilization of asphyxiating gases as weapons on their own. This included the use of a cloud of gas that was produced with the sole purpose to engulf an enemy position, used as a single weapon with no other explosive element. The declaration also imposed a condition on the use of gases built into an artillery shell or bullet. The wording, however, was not clear in the condemnation of the use of gas in warfare. It left room for its meaning to be questioned with regard to what gas constituted a poison, whether the use and further development of gas-based weapons was justifiable in circumstances of retaliation, and what exactly was meant by the term *mass slaughter.*

Only one case was heard under terms of the Hague Convention of 1899—the North Sea Incident in 1904, when Russian boats fired upon a British naval ship—before the Second Peace Conference at The Hague on October 18, 1907. (The second convention entered into force on January 26, 1910.) Despite these two Hague agreements, chemical weapons were used by both sides in World War I, by Italy in Ethiopia and by Japan in China during the 1930s, and by both sides during the Iran-Iraq war in the 1980s.

The international community has established a regime to ban the use of chemical weapons in warfare and also to ban the very possession of chemical weapons. The Geneva Protocol (Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous, or Other Gases, and of Bacteriological Methods of Warfare) was signed on June 17, 1925, and entered into force on February 8, 1928. The most recent treaty that has banned the production and use of chemical weapons is the Chemical Weapons Convention (CWC), signed in 1993, which entered into force in 1997. The CWC complements the 1972 Biological and Toxin Weapons Convention.

—*Glen M. Segell*

See also Biological and Toxin Weapons Convention (BTWC); Chemical Weapons Convention (CWC); Geneva Protocol

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HALABJA INCIDENT

The Iraqi use of chemical weapons on the northern Iraqi village of Halabja in 1988 illustrates the immediate and long-term damage that such weapons can inflict. The attack also demonstrates how

Saddam Hussein's chemical attack on Halabja in 1988 resulted in the death of about 5,000 people. (Faleh Kheiber/Reuters/Corbis)

chemical warfare agents can be used against an adversary, and it shows some of the possible motives for employing these weapons. Although allegations that Iraq used chemical weapons against Iranian and Shi'ite territories also exist—at least twenty similar attacks against smaller northern Iraqi villages occurred in 1987—none matched the scale or intensity of the chemical assault on Halabja.

On March 16, 1988, the Iraqi military, at the time also engaged in an 8-year-long war with Iran, launched a 3-day artillery and air attack against the Kurdish town of Halabja in northern Iraq. In addition to the chemical nerve agents tabun, sarin, soman, and possibly VX, Iraq employed the blister agent mustard in artillery and aerial munitions to eliminate segments of the Kurdish population that had become an irritant to Saddam Hussein. Some sources suggest that this attack was launched to experiment with different nerve agents. Estimates place the number of dead in the immediate aftermath of the chemical attacks at approximately 5,000. At the end of the operation, a total of 12,000 are believed to have perished. This was the largest chemical weapons attack against a civilian population.

The town of Halabja is situated approximately 15 miles west of the border with Iran. At the time, the town, with a total population of 40,000, was home to roughly 8,000 Kurds. As was the case with most of Iraqi Kurdistan, the inhabitants of Halabja supported the Peshmerga. These Kurdish fighters (the name *Peshmerga* literally means "those who face death") were in a state of perpetual revolt against the regime of Saddam Hussein, and they used the town as a safe haven and sometimes as a base of operations for insurgency against Saddam's Ba'ath regime. Whenever the tide of battle would turn and Iranian forces controlled the region, Halabja was used as a staging area for joint Iranian-Peshmerga operations against nearby Iraqi positions.

On the morning of March 16, 1988, following a successful joint attack between the Peshmerga and the Iranian military on Iraqi outposts surrounding the town, the Iranian Revolutionary Guard infiltrated and passed through Halabja. The town's residents assumed that an Iraqi retaliatory air strike was imminent due to the town's collusion with Iranian Revolutionary Guards, and began to take cover in cellars and other underground shelters. Eyewitness accounts reported that at approximately 10:30 A.M., an Iraqi helicopter appeared over the horizon, snapping aerial photographs and taking video of the town. Approximately one-half hour after the helicopter vacated the area, the Iraqi army began an artillery barrage on Halabja from a position in the nearby town of Sayid Sadiq. Shortly after the artillery bombardment began, Iraqi warplanes began to drop what is believed to have been napalm near the northern area of the town.

After 3 hours, the pace of the opening barrage began to taper off. As the explosions slowly subsided, a different sound was heard. As one survivor noted, it was like "pieces of metal just dropping without exploding." These were the first of many chemical weapons canisters that were dropped by Iraqi aircraft, including by helicopters. Another helicopter soon returned to Halabja, this time dropping small pieces of paper. It was later understood that the Iraqis were attempting to assess the wind direction and speed for delivery of their chemical weapons.

Coinciding with the sound of falling metal, survivors described a strange odor filling the air, reminiscent of a cocktail of garbage, eggs, garlic, and apples. As the inhabitants of the town began to panic, they once again rushed to the perceived safety of their cellars and underground bunkers. Tragically, these makeshift shelters quickly filled with the deadly mixture of gases, killing everyone inside.

The chemical cloud engulfed the town, contaminating water, land, and air. Those who ran became disoriented, dying in the streets as the wind blew the gas in all directions. Those who stayed behind in the shelters met similarly grisly fates, choked by the invisible fumes.

Each gas attack lasted approximately 45 minutes, with 15 minutes between each wave. The Iraqis made a total of fourteen sorties, each using between seven and eight warplanes.. The attack ended on the following day. Iranian forces returned and occupied the town shortly after the attack subsided, evacuating many of the sick and wounded to hospitals in Tehran.

Ten years after the attack, Dr. Christine Gosden, a British physician, became the first Westerner to visit the area, documenting the vast residual effects of the attack on the town and its people. In an April 22, 1998, letter to a U.S. congressional committee, Gosden noted that no systematic research had yet taken place to document the total impact of the chemical attack on Halabja. She reported, however, that reproductive dysfunction, congenital malformations, and long-term neurological and neuropsychiatric effects (particularly in those who were children at the time of the attack) found among the town's residents may have been linked to chemical exposure suffered during the 1988 attack.

Iran utilized the event for propaganda purposes, stressing that this particular atrocity was committed by Saddam's military, and many in the West echoed the sentiment that this chemical attack constituted a crime against humanity. In October 1988, the U.S. State Department declared: "We have publicly and unambiguously opposed the illegal use of chemical weapons in the Gulf War and by Iraq against the Kurds. We have worked to obtain Security Council resolutions condemning chemical weapons usage during the Gulf War" (Golden and Wells, p. 368). The incident at Halabja nearly led the Reagan administration to impose economic sanctions against Iraq, but it did not cut off all military assistance. The U.S. government has been criticized for its collaboration with Iraq in its war with Iran, given the Iraqi use of chemical weapons against Iranian forces and Kurdish civilians. Other foreign governments and businesses have been implicated in these attacks because they provided the Iraqi government with the means to produce and deliver chemical weapons.

—Brian L'Italien

See also Blood Agents; Iran-Iraq War; Nerve Agents

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HEARTWATER *(COWDRIA RUMINANTIUM)*

Heartwater is an acute infectious disease that causes serious morbidity and mortality in livestock and wildlife. The causative agent, *Cowdria ruminantium,* is a rickettsial bacterium that is transmitted by ticks when they feed on susceptible hosts. A consistent finding in animals infected with *C. ruminantium* is the abnormal accumulation of fluid in body tissues, leading to, among other problems, hydropericardium (literally, water surrounding the heart). Of considerable concern to U.S. officials are the lethality of infection in susceptible animals, the potential for rapid transmission to domestic livestock through infected ticks, and the importation of symptomatic animals capable of serving as a source of infection for other animals. The epidemic transmission of heartwater disease could have a catastrophic impact on U.S. livestock production and thus constitutes a potential biological threat to domestic agribusiness and related economic interests.

Cowdria ruminantium is endemic to sub-Saharan Africa and has been responsible for epidemics in both livestock and indigenous wildlife in that region. The most common vector of the bacterium is the tropical bont tick, *Amblyomma variegatum,* which was probably introduced to several Caribbean islands about 100 years ago in cattle imported from Senegal (formally French West Africa). The tick vector is now established throughout the Caribbean, and the disease has been aided in its dispersion by migratory birds such as the cattle egret. Of particular concern has been the migration of the cattle egret from the Caribbean to Florida, illustrating a potential route for the dissemination of *C. ruminantium* into the southeastern United States from the Caribbean islands. Heartwater disease is a serious threat, and its introduction could easily pass unnoticed until an epidemic occurred. Officials in the United States and other countries with developed livestock industries have several specific concerns about heartwater:

- Infection with *C. ruminantium* is difficult to diagnose in the field.
- Heartwater infection demonstrates variable expression in terms of causing disease, ranging from 40 to 100 percent in various livestock and many wildlife species, including white-tailed deer.
- Antibiotics such as tetracycline, doxycycline, and rifamycin are effective against heartwater, but only if administered early in the course of infection; delayed treatment has significantly decreased efficacy.
- Ticks, potentially those infected with *C. ruminantium,* can travel on a number of wild animals, reptiles, and birds.
- Tick species indigenous to the United States, such as *Amblyomma maculatum* and *A. cajennense,* are effective vectors for heartwater under experimental conditions.

Technical Details

Cowdria ruminantium is a rickettsial organism genetically related to *Ehrlichia* species, a group of bacteria that are known for causing numerous animal and human diseases. The bacterium is an obligate intracellular pathogen; that is, it requires a host to survive and replicate. *C. ruminantium* invades and multiplies in vascular endothelial cells (inner cellular lining) in capillary beds throughout an infected animal. Transmission is typically through the bite of an infected *Amblyomma* tick, although vertical transmission (i.e., from infected cow to calf) is also possible. The clinical signs and pathology of heartwater are caused by the degeneration of endothelial cells lining the microvasculature of tissues and organs in an infected animal. Vascular permeability—the tendency of fluid to leak from blood vessels—is severely altered with heartwater infection, resulting in the accumulation of fluids in body cavities and interstitial (in between tissue) spaces. The infection is characterized by fever, signs of neurological impairment and nervousness, and convulsions. Death can occur within 1 to 2 weeks of acute onset.

Efforts to mount an effective and coordinated program to eradicate tick vectors of heartwater in the Caribbean have met with limited success in their initial phases. Increased vigilance at the point of entry for exotic wildlife, birds, and reptiles is needed to minimize the importation of infected ticks or animal reservoirs of *C. ruminantium.* Heartwater remains a serious concern to U.S. agribusiness, in particular to domestic livestock.

Animals demonstrate protective immunity after exposure to *C. ruminantium,* suggesting that vaccination may be an effective countermeasure against infection. An attenuated strain of *C. ruminantium* has shown efficacy in controlled trails and may serve as the basis for a preliminary vaccine program. Strain variation and questionable cross-strain protection introduce considerable uncertainty into vaccine development research, however.

—*J. Russ Forney*

See also Agroterrorism (Agricultural Biological Warfare); Vector

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HEMORRHAGIC FEVERS

Hemorrhagic fever viruses (HFVs) damage the vascular system and are often (as their name implies) accompanied by hemorrhage, their unifying clinical feature, and by impairment of the body's ability to regulate itself, leading to fever. HFVs cause multisymptom syndromes, meaning that multiple organ systems in the body are affected. There are four distinct families of HFVs that have different clinical and epidemiological manifestations. All HFVs are zoonotic viruses, meaning they reside in animal or arthropod hosts, some of which are still unknown. Natural occurrence of this disease is usually restricted to the habitat of the host animal or arthropod vector. The viruses vary in their transmission but overall can be transferred to humans through the bites of arthropods (ticks, mosquitoes), contact with hosts (often rodents) or their droppings, exposure to infected livestock, or sometimes person-to-person contact. Based on numerous criteria, HFVs have been identified as biological agents that carry particularly serious risk if used as biological warfare (BW) agents against military personnel or civilian populations. Additionally, some HFVs can establish a large focus of infection in the local environment's animal hosts, which could exacerbate the impact of an attack.

History and Background

The Centers for Disease Control and Prevention (CDC) has designated two of the families of HFVs (filoviruses and arenaviruses) as Category A biological agents, meaning that they pose the greatest potential for "adverse public health impact" to the United States. This is in response to the severity of disease, the lack of treatments or vaccines, and the level of disruption and fear potentially caused by their large-scale dissemination. When evaluating the threat from potential disease agents, the U.S. Working Group on Civilian Biodefense, which sees HFVs as a serious risk to civilian populations, also took into consideration previous attempts to weaponize these agents.

State-run programs to research the weaponization of HFVs were known to have existed in the United States, the former Soviet Union, and Russia, with additional reports of potential ongoing programs in other states, including North Korea. The United States pursued research on Junin (responsible for Argentinean HF), Hantaan (responsible for Korean HF), Machupo virus (responsible for Bolivian HF), Lassa, yellow fever, Dengue, and Rift Valley fever virus. (Rift Valley fever, for example, was tested by the United States as a potential weapon in field aerosol tests, but it was never weaponized.) These programs were discontinued in 1969 when offensive biological weapons research and development was halted by order of President Richard M. Nixon. Despite having signed the 1972 Biological and Toxin Weapons Convention, however, the former Soviet Union continued with its own BW program. As far as is known from open sources, Soviet BW scientists successfully weaponized Marburg hemorrhagic fever and conducted research into the weaponization of Ebola (which was less successful), machupo, junin, Lassa, and yellow fever. Although research into biological weapons continues until 1992, it is not known if further research in HFV research continued by Russian military scientists. North Korea is suspected of having weaponized yellow fever.

Technical Details

All identified HFVs are simple, negative strand (a category of viruses with antisense, nonmessenger-RNA capable) RNA viruses that have lipid envelopes (fat-based covering making viral particles somewhat vulnerable), rendering them relatively susceptible to detergents, low-pH environments, and household bleach. They are stable at neutral pH, however, especially in the presence of proteins. Some of the viruses naturally aerosolize during disease spread and thus tend to be stable and highly infectious as a fine-particle mist. With the exception of dengue, all HFVs can be transmitted as aerosols to laboratory animals. It is this feature that makes these viruses attractive as potential BW agents for state-level programs and perhaps terrorist organizations.

The 1995 Ebola virus outbreak in Kikwit, Zaire, killed 245 people. (Patrick Robert/Corbis Sygma)

What is known about VHFs and their associated diseases has been deduced from clinical observation (records of natural outbreaks) or experiments on various nonhuman primates. The sporadic appearance of these diseases, often in areas not best equipped to record relevant epidemiological data, however, has caused information to be limited. Additionally, it is not known whether an intentional attack would follow similar patterns as naturally occurring disease outbreaks.

VHF is a disease associated with fever and bleeding. Early symptoms are nonspecific and include fever, rash, body aches, headaches, and fatigue. The characteristic bleeding can occur in the later stages of disease. The incubation time for VHFs is roughly 2 to 21 days, and the case fatality rate ranges from 0.5 to 90 percent, depending on the agent. When death occurs, it is usually 1 to 2 weeks after exposure and occurs as a result of multiorgan system failure preceded by hemorrhagic bleeding and shock. Diagnosis is difficult and usually depends on clinical symptoms, because few laboratories are equipped to recognize these pathogens in tested blood or tissue. Patient travel history, usually taken into consideration in diagnosis of VHF, may be of limited use in the event of an intentional attack.

VHFs are caused by four distinct viral families: *Filoviridae, Arenaviridae, Bunyaviridae,* and *Flaviviridae.* Marburg and Ebola are the only known members of the *Filoviridae* family thus far identified. Marburg virus was first detected in 1967 when laboratory workers in Marburg, Germany, and in Yugoslavia became infected after handling tissues from green monkeys shipped from Africa. The animal host or mechanism of initial infection for this virus is unknown; however, infected individuals can spread the virus through bodily fluids during and after illness, as observed by a transmission occurring through semen up to 7 weeks after clinical recovery. There is currently no treatment or approved vaccine for this rare disease, which has a case fatality rate between 23 and 25 percent.

Ebola HF is one of the most virulent diseases known to humans, with a fatality rate of 50–90 percent of all clinically ill cases. Ebola was first identified in 1976 outbreaks that occurred in Zaire (now the Democratic Republic of Congo) and Sudan. These viruses later proved to be distinct species and were named after the countries in which they first appeared. Two additional subtypes were later identified, Ebola-Reston and Ebola-Ivory Coast, with the former causing disease in nonhuman primates but not in humans. As with Marburg, the natural reservoir for this virus is unknown but is suspected to be an animal that is native to the African continent. The initial mode of infection is not understood, but the virus can be spread by contact with bodily fluids and possibly through intact skin, as both sweat glands and adjacent skin tissues have been shown to contain viral particles. As in the case of Marburg HF, there is currently no treatment or vaccine for Ebola. The incubation time for Marburg and Ebola ranges from 3 days to 3 weeks following exposure. Although it has never been directly demonstrated in human cases, airborne transmission of filoviruses cannot be ruled out.

The viruses in the family *Arenaviridae* can be divided into Old World and New World, all of which are transmitted through a rodent reservoir. For these viral diseases, contact with the excreta of infected rodents (often via infectious aerosols) is the primary mode of infection. Human-to-human transmission can occur through bodily fluids, and airborne transmission has also been suspected in these cases. There have been no reports documenting transmission during the incubation period. Lassa fever, one of the Old World viruses, is an acute illness with an incubation period of 6 to 21 days and a fatality rate of 15 percent among hospitalized patients. The New World viruses include junin virus (causes Argentine HF), machupo virus (causes Bolivian HF), Guanarito virus (causes Venezuelan HF), sabia virus (causes Brazilian HF), and a newly identified HFV that first appeared in California in 1999–2000. Each of the viruses has a unique species of rodent that serves as its natural reservoir and an incubation period of between 7 and 15 days. Many of the diseases continue to appear sporadically in their natural environment. The use of ribavirin, an antiviral medication, has proved helpful in the treatment of arenaviruses. With the exception of junin virus, approved vaccines are not available.

Members of the *Bunyaviridae* family are usually spread by arthropod carriers or exposure to infected animal tissues, with one notable exception. Hantavirus is transmitted through contact with infected rodents and their excreta. After the incubation time of 7 to 28 days, there is little treatment beyond supportive care for patients infected with hantavirus. Rift Valley fever is spread to humans and other animals by a wide variety of mosquito species as well as through infectious bodily fluids. Domestic livestock such as sheep, cattle, buffalo, and goats are susceptible to Rift Valley virus. Most cases of Rift Valley are relatively mild, with an overall human fatality rate of less than 1 percent. However, a small portion of those infected develop a hemorrhagic syndrome that has a 50 percent case fatality rate. The incubation period is 2–6 days, and there is currently no treatment or vaccine available. Other viruses in this family spread by ticks, such as Crimean-Congo HF, Xinjiang HF (China), and the various agents of hemorrhagic fever with renal syndrome (HFRS). The latter includes hantavirus, which continues to inflict a heavy burden of disease through natural outbreaks. In terms of BW, however, there are substantial technological difficulties in weaponization of such viruses, notably in culturing them, and as a consequence, hantavirus is not considered a major threat in the United States.

The last family of HFVs, *Flaviviridae,* includes viruses that are naturally transmitted by arthropods. One of these, yellow fever virus, remains silent in the body for an incubation period of 3–6 days, after which the disease manifests itself in two phases. The first, or “acute,” phase, from which most people recover, can be followed by a “toxic” phase in about 15 percent of patients. Of these, about 50 percent will die within 10–14 days. Although there is no specific treatment for the disease, an effective vaccine does exist for yellow fever. However, the vaccine would have limited use in the event of a bioterror attack due to the virus’s short incubation time. There have been no reported cases of person-to-person or hospital spread of the disease, although infection can result from inhalation of aerosols.

Dengue HF is caused by one of four distinct viral serotypes (DEN-1, DEN-2, DEN-3, and DEN-4) transmitted by a mosquito vector, resulting in a spectrum of clinical manifestations based on serotype and the predisposition of the patient. Incubation time is between 2 and 10 days. Although many cases resolve themselves naturally, untreated patients that go into shock have a 40 to 50 percent fatality rate; this drops significantly if intensive care is available. Currently, there is no vaccine for Dengue HF. Because *Flaviviridae* viruses are carried by arthropod vectors, there is a theoretical risk of the disease being established in the environment in the event of large-scale exposure.

Current Status

Different HFVs are endemic to various geographical regions. Outbreaks that occur beyond their natural geographically restricted areas could be from one of the following sources: (1) imported from a region where it is endemic; (2) resulting from laboratories doing research on these organisms or receiving specimens from patients with fevers of unknown origin; (3) imported from infected rodents or laboratory research animals; or (4) an act of biological warfare. Making a determination among these causes presents significant challenges.

Diagnosis of VHF should be made based on clinical criteria, with laboratory testing used to conclusively confirm or rule out disease. In the event of a large attack, the current laboratory capacity would likely prove insufficient because there are few facilities properly equipped to deal with these pathogens. There are limited quantities of ribavirin, an antiviral drug that has been shown to be useful in treatment of *Arenaviridae* and *Bunyaviridae* but has not been approved by the FDA for treatment of VHFs. Ribavirin has also been linked to birth defects in pregnant women, and safe doses have not been well established in children. In an emergency situation, however, the administration of ribavirin and other new antivirals in these populations should not be ruled out. Treatment for people who may have been exposed but are not showing clinical symptoms is not recommended. Ribavirin has not shown much effectiveness against filoviruses or flaviviruses. It has been recommended that intravenous and oral ribavirin be added to the U.S. National Pharmaceutical Stockpile. In any event, infection control measures will prove critically important in any large-scale outbreak of VHFs.

Developing Technologies

There are large gaps in knowledge about HFVs due to limited data about the diseases and the need to perform research in high-safety laboratory situations. Mechanisms of disease outbreaks, airborne transmission, and rapid and safe diagnostic methods all need to be further researched or developed. Better treatments and vaccines are needed; however, the diversity and relative unknown nature of disease manifestation have complicated this pursuit. Vaccines exist for yellow fever, Rift Valley fever, and Junin (Argentine HF); the junin vaccine may give cross-protection for Machupo (Bolivian HF). Only the yellow fever vaccine is licensed by most national drug authorities, and there is a limited global supply and capacity to deliver the vaccine. Following an attack using this viral agent, the prophylactic use of the vaccine would not be very effective, because the time needed to raise immunity after vaccination is longer than the incubation period for the disease. Other vaccines are being researched and developed against filoviruses and Lassa fever, but these efforts are hampered by the strict safety protocols necessary to conduct research.

—Elizabeth Prescott

See also Crimean-Congo Hemorrhagic Fever; Marburg Virus; Rift Valley Fever

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HERBICIDES

Herbicides are weed killers. It is estimated that about 1,500 species of weeds cause serious economic losses to American farmers. Fifty-three percent of the herbicides in the United States is used to aid in corn production, 21 percent is used for soybeans, 6 percent for wheat, 5 percent for cotton, and 5 percent for other crops.

Herbicides commonly used in the United States for large-scale agriculture are shown in Figure H-1 and Table H-1.

Fig. H-1: Structures of herbicides used in large-scale agriculture in the United States

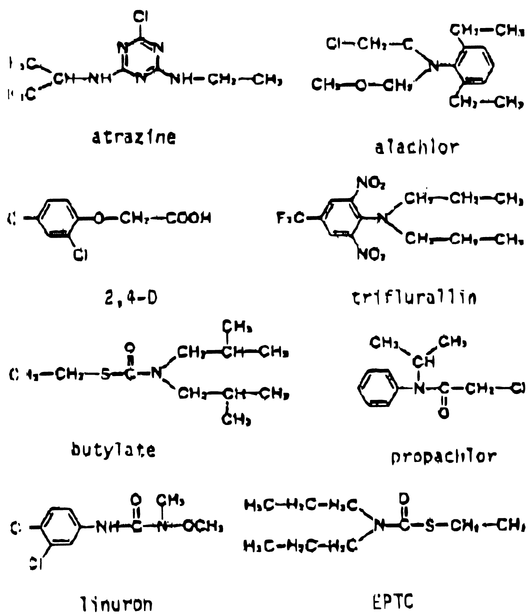


Table H-1: Herbicides Used in Large-Scale Agriculture in the United States

Common Name	*Trade Name*	*Amount Used (lbs.)*	*Percentage of Total*
atrazine	A Atrex	90.3 x 10^6	24.1
alachlor	Lasso	88.5 x 10^6	23.7
2,4-D	Weeder 64	38.4 x 10^6	10.3
trifluralin	Treflan	28.3 x 10^6	7.6
butylate	Sutan	24.4 x 10^6	6.5
propachlor	Bexton	11.0 x 10^6	2.9
EPTC	Eptam	8.6 x 10^6	2.3
linuron	Lorox	8.4 x 10^6	2.2
others	—	76.0 x 10^6	20.3

Some herbicides are water insoluble; these are dissolved in organic solvents for efficient distribution. For water-based weed killers, however, water-soluble herbicides are used. The best examples of water-soluble herbicides are diquat, paraquat, morfamquat, and chlormequat chloride. Because paraquat—a widely found and used herbicide—is water soluble, occasionally it is used for homicides by mixing it with juice or soft drinks and giving it to a victim to drink. Injection of paraquat into the human body is very dangerous, causing damage in liver and kidney tissues. Contact with paraquat causes skin, mucous membrane, and cornea irritation.

Phenolic and phenoxy-type herbicides are other commonly used types. Phenolic herbicides are usually nitro- and chloro-derivatives of phenol. Examples are dinitrophenol, dinitro-ortho-cresol, and pentachlorophenol. These phenolic herbicides kill weeds by contact with foliage rather than by uptake through the roots. Thus, they also are called contact herbicides. Phenoxy-type herbicides were used as defoliation agents during the Vietnam War by the U.S. Army.

There are many varieties of herbicides, and the mechanism of herbicide action is different depending on the compounds. The compounds 2,4-D and 2,4,5-T are similar in action to the plant hormone auxine. They promote rapid weed growth in a short time, creating an imbalance in the weeds' metabolisms that causes the weeds to die. Amitrole inhibits the biosynthesis of chlorophyll and carotenoids, which are essential for proper plant growth. Atrazine blocks the breakdown of water molecules into 2H and 1/2 O_2, which is a crucial step for photosynthesis in plants. Diuron inhibits the breakdown of water molecules and inhibits the enzymatic step between Q and plastoquinone in the photosystem II metabolic pathway, a critical step in photosynthesis.

Bipyridylium (Paraquat, Diquat) herbicides compete with electron acceptors, which are necessary for continuous exchange of energy in photosystem I in photosynthesis, causing weeds to die. Dinitrophenol, dinitro-ortho-cresol, and pentachlorophenol are toxic because they uncouple the oxidative phosphorylation used for energy transfer process in weeds.

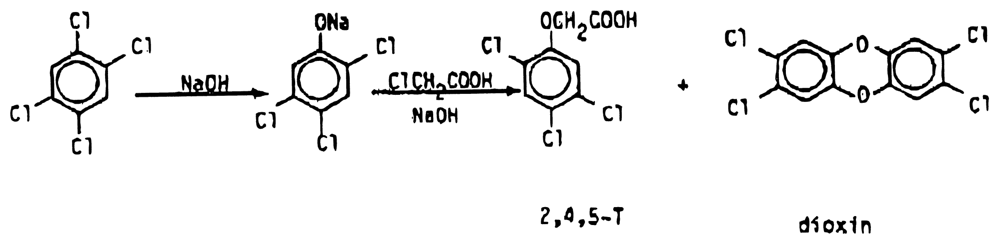
Herbicides are designed to kill plants; they generally have low toxicity in humans, with the exception of paraquat and endothal. Phenolic herbicides, however, are moderately toxic to humans. In mammals, they cause fever, sweating, fast respiratory and heart rates, and dehydration.

American troops in Vietnam were the first to use herbicides extensively for military purposes (e.g., to defoliate tropical vegetation used for cover by the enemy). The most well known herbicide used during the Vietnam War was Agent Orange, consisting of 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxy acetic acid (2,4,5-T). But U.S. forces also used other herbicide formulas called Agent White, Agent Blue, Agent Purple, Agent Pink, and Agent Green. They are shown in Table H-2.

Table H-2: Herbicides Used in the Defoliation Operation in Vietnam from 1965 to 1971

Code Name	*Herbicide*	*Quantity (gal.)*	*Period of Use*	*Dioxin (ppm)*
Orange	2,4-D; 2,4,5-T	10,646,000	1965–1970	1.98
White	2,4-D; picloram	5,633,000	1965–1971	—
Blue	cacodylic acid	1,150,000	1962–1971	—
Purple	2,4-D; 2,4,5-T	145,000	1962–1965	32.80
Pink	2,4,5-T	123,000	1962–1965	65.60
Green	2,4,5-T	8,200	1962–1965	65.60
Total		17,705,200		

Fig. H-2: Manufacture of 2, 4, 5-T and the by-product formation of dioxin



Agent Orange created environmental and health problems due to dioxin contamination (2,3,7,8-tetrachlorodibenzodioxin); when 2,4,5-T was produced (see Figure H-2), dioxin was produced as a by-product. The lethal dose of dioxin in rats is 1.0 g/kg by the oral route, meaning that dioxin is 100,000 times more toxic than 2,4,5-T. Although dioxin is highly toxic in nature (especially in soil), it degrades into less toxic products, albeit very slowly.

About 369,000 Vietnam veterans received treatment in Veteran's Administration (VA) hospitals for Agent Orange–related health problems. Among them, 9,600 were admitted to hospitals for further intensive care. About 17,000 veterans requested sickness compensation. The U.S. Department of Defense, however, has claimed that Agent Orange had nothing to do with veterans becoming sick and that the U.S. government had no obligation to offer compensation. Many veterans and their families were unsatisfied with this decision and filed suit against the U.S. government. To avoid costly and lengthy litigation, the U.S. government settled the veterans' claims out of court for $180 million.

After the Vietnam War, about 20,000 gallons of Agent Orange remained in storage. The U.S. Army destroyed this stockpile on an incineration ship in the middle of the Pacific Ocean at temperatures of 1,000–1,500° centigrade. High temperatures are essential for destruction of Agent Orange; otherwise, dioxin can be formed.

The problem of dioxin was not restricted to Vietnam. In 1976, a chemical plant in Seveso, Italy, accidentally released dioxin in a densely populated area. Because of the dioxin problem, the Environmental Protection Agency (EPA) has cancelled the use of 2,4,5-T on most food crops. In 1982, dioxin contamination was found in Times Beach, Missouri, and the EPA offered to buy the whole town to solve the problem. However, to date there are no studies to show that the Seveso incident or the Missouri case resulted in increased incidence of human disease linked to dioxin.

—*Anthony Tu*

See also Agent Orange; Biological Warfare; Dioxin

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I

INDIA: CHEMICAL AND BIOLOGICAL WEAPONS PROGRAMS

Chemical Weapons

India's first contact with chemical warfare (CW) equipment and organization in the modern era probably began in 1920. When India was still a British colony, mustard was brought into India to deal with anticolonial rebels in the northwest.

Since World War II and the independence of India (1947), little has been revealed concerning India's offensive CW capability. In June 1997, India declared to the Organization for the Prohibition of Chemical Weapons (OPCW) that it possessed chemical weapons. Precursors—chemicals that could be used to make CW agents such as sulfur mustard—were also declared by India, including chloroethanol. According to Chinese CW defense sources, India possesses five chemical weapons production and storage facilities with 1,000 tons of CW agents in its stockpile, "making India the third largest chemical weapons possessor after the United States and Russia" (Zhang, Yuan, and Xiong, p. 43). Most of India's stocks were estimated by the Chinese military to have been in the form of mustard agent. As a member of the Chemical Weapons Convention (CWC), India is obligated to destroy its entire stockpile by 2007.

Biological Weapons

India ratified the Biological and Toxin Weapons Convention in 1974. Despite some open source reports that suggest that India possesses biological weapons, none of these allegations can be confirmed.

During the Indo-Pakistan War in 1965, the Indian intelligence apparatus became suspicious when they detected an outbreak of scrub typhus in northeast India. Caused by the organism *Rickettsia tsutsugamushi,* the outbreak of scrub typhus during the Indo-Pakistan War was undoubtedly a natural consequence of conflict—due, for example, to the disruption of sanitary measures. Similarly, in 1994, an outbreak of plague in Surat was deemed suspicious. Some Indian security specialists believed that outside actors—perhaps terrorists—might have been responsible for the plague outbreak. However, there is no evidence to support such a claim, and it appears most likely that the Surat plague outbreak was due to natural causes.

There were also unfounded rumors of bioterrorism during the dengue outbreak in 1996 in Delhi. Molecular studies of isolates from this epidemic showed an especially virulent type of the disease, and the director of the Indian Veterinary Research Institute was not willing to rule out a foreign point of origin. This case, however, was also most likely a natural outbreak of dengue.

Like many countries, India conducts research into defenses against biological warfare (BW). Military-related research into possible biological weapon threats is conducted at India's Defense Research and Development Establishment at Gwalior. Having a significant capacity to produce pharmaceuticals, notably vaccines, India has the potential to produce large quantities of BW agents should it desire to do so. There is no evidence from open sources, however, that India has ever pursued an offensive BW program.

—Claudine McCarthy

See also: Typhus (Rickettsia Prowazekii)

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INVERSION

Inversion is a meteorological phenomenon that occurs when the ground is cooler than the air above it, usually during early morning or dusk. Typically, there is little air turbulence in an inversion, and aerosols are not dissipated as rapidly as they would be under other conditions (i.e., air conditions known as neutral and lapse; see below). Inversions are generally considered to be optimum for the delivery of chemical or biological warfare agents. According to Chinese military experts in chemical warfare, "The effect of temperature inversion makes it difficult for contaminated air to disperse, making it stick close to the ground as it moves, and now a high concentration of agent is maintained with harmful effects lasting over a long period" (Cheng and Shi, p. 45).

Neutral conditions are less favorable for CBW agent delivery. In neutral conditions, the ground temperature is about the same as the layer of air above it (up to about 12 feet). There is some turbulence from convection currents due to fluctuations caused by warmer air, and winds are light to moderate. Such conditions are less ideal for CBW agent release. Finally, in the condition known as lapse, the temperature of the air is cooler than that of the ground. Cooler air moves toward the ground, creating air turbulence. This usually occurs during late morning and afternoon (usually with clear skies) and is the least favorable environment for disseminating aerosols.

During the Cold War when the United States possessed an offensive chemical weapons program, tables were used to calculate the effectiveness of nerve agents against enemy targets. Depending upon wind speed, ambient temperature, and inversion/neutral/lapse conditions, the table would tell the number of shells needed to contaminate a certain number of hectares of ground. During inversion, with moderate (20 degrees C) temperature and slow wind velocity, for example, the number of 105-millimeter sarin nerve agent howitzer shells needed might be as few as two or three per hectare. In contrast, under lapse conditions with high wind and high ambient temperatures, dozens of shells or more might be required per hectare.

Inversion also plays a key role in biological warfare. As seen in Table I-1, the behavior of particles under inversion, or lapse conditions will in large part depend upon their diameter. Some early calculations of particle behavior based on particle size showed that, with a wind velocity of about 5 miles per hour, most particles of 0.8 microns can remain airborne for 10,000 yards. But another phenomenon occurs during inversion. As particles increase in size, at a lower wind speed (2 mph), they fall out of the air more rapidly.

Awareness of inversion or lapse conditions is useful for offensive use of chemical and biological weapons. Because inversion conditions are best suited for the delivery of CBW aerosols, however, militaries and civil defense planners can also take into account meteorological data to mitigate the effects of chemical or biological weapons.

—Eric A. Croddy

See also: Aerosol; Inversion; Line Source; Point Source

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Table I-1: Airborne Fractions of Aerosol Clouds Remaining Aloft in Lapse and Inversion (V=velocity of wind)

	Lapse (V=5mph)				*Inversion (V=2mph)*			
Distance Downwind	*Drop Diameter (microns)*	*Drop Diameter (microns)*	*Drop Diameter (microns)*	*Drop Diameter (microns)*	*Drop Diameter (microns)*	*Drop Diameter (microns)*	*Drop Diameter (microns)*	*Drop Diameter (microns)*
Yards	0.8	8	12	24	0.8	8	12	24
100	0.99	0.98	0.96	0.85	0.99	0.89	0.76	0.32
500	0.99	0.96	0.94	0.78	0.99	0.83	0.64	0.16
1,000	0.99	0.96	0.93	0.74	0.99	0.78	0.58	0.11
5,000	0.99	0.95	0.90	0.65	0.99	0.69	0.42	0.03
10,000	0.99	0.95	0.88	0.59	0.99	0.63	0.37	0.02

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IRAN: CHEMICAL AND BIOLOGICAL WEAPONS PROGRAMS

Although Iran has limited indigenous skills and resources to manufacture weapons of mass destruction (WMD), it has consistently figured prominently in evaluations of international WMD proliferation threats. Unstable relations between Iran and the United States following the Islamic revolution of 1979 exacerbated concerns about Iranian weapons aspirations. Iran's efforts to acquire weapons capabilities have, as a result, been broadly curtailed by U.S. efforts to prevent arms and technology transfers between U.S. allies and Iran.

Iran's WMD aspirations gained additional urgency following the Iran-Iraq war, in which Iraq demonstrated superior WMD capabilities. Iran's conventional arsenal was also devastated in the war, and Iran turned to the Soviet Union for assistance in reconstituting its military. The Soviet Union viewed its cooperation with Iran as a means of extending its own influence in the pivotal Persian Gulf region, and it formally agreed in 1989 to bolster Iran's military capacity. Iran has also received extensive military assistance from China and North Korea.

Chemical Weapons

Iran's chemical weapons program is its most advanced effort to create and deploy weapons of mass destruction. Iran initially received chemical agent precursors from the United States, Germany, and Japan, and it received production technology from Germany and Hungary. After the revolution in 1979, China became Iran's primary supplier of these materials. Iran is reportedly close to self-sufficiency in terms of possessing a chemical weapons industry and could possibly become a supplier to other countries.

Iran is believed to have initiated a chemical weapons program in the mid-1980s, in response to the use of chemical weapons against it during its war with Iraq. Reports indicate that it began to stockpile cyanogen chloride, phosgene, and mustard after 1985 and to produce nerve gas in 1994. In 2000, U.S. intelligence analysts reported that Iran possessed at least several hundred metric tons of weaponized and bulk chemical agents, including nerve, blood, blister, and choking agents, and that it has attempted to obtain weapons-relevant technology, training, and chemicals from China and Russia. Iranian opposition groups have also reported that Iran has produced VX nerve gas and aflatoxin.

Iran signed the Chemical Weapons Convention in 1997 and submitted a declaration of its holdings as required by its membership. Iran disclosed that it had a chemical weapons program in the final months of the Iran-Iraq war, during which it was exposed to chemical weapons attacks by Iraq, but it has denied all accusations that it has an ongoing program. It has accepted visits from inspectors of the Organization for the Prohibition of Chemical Weapons (OPCW), who have not found evidence of treaty violations.

Biological Weapons

Iran initiated a biological weapons program in the 1980s during its war with Iraq. Little information, however, is publicly available about Iran's efforts to acquire biological weapons. Some observers suspect that Iran has a biological weapons laboratory at Damghan, has produced small quantities of biological weapons agents such as anthrax bacteria and botulinum toxin, and has weaponized several biological agents. Some experts doubt that Iran possesses stockpiles of biological agent but instead believe that it has created surge capabilities that would allow it to build a biological weapons stockpile on short notice. Iran has denied all allegations about developing or stockpiling biological weapons and maintains that it adheres to the Biological and Toxin Weapons Convention, which it ratified in 1973.

U.S. intelligence agencies have suggested that biomedical research conducted at institutions in Iran has been used in support of a biological weapons program and that Iran has received biotechnology from Russian research facilities. Some experts have also suggested that Iran likely accelerated its biological weapons program following revelations about Iraq's biological weapons program in 1995. Press reports have also indicated that Iran has recruited Russian weapons scientists to work on its biological weapons programs.

—*Jacqueline Simon*

See also: Halabja Incident; Iran-Iraq War

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IRAN-IRAQ WAR

The Iran-Iraq War was an armed conflict between Iran and Iraq that lasted from September 1980 to August 1988. It witnessed the first confirmed use of chemical weapons in combat since World War I and the first use of nerve agent in warfare. Although precise figures are unavailable, the conflict produced more than 1.5 million war-related casualties.

The war was launched by Iraqi president Saddam Hussein, ostensibly over a territorial dispute over the Shatt al Arab, a waterway that empties into the Persian Gulf and forms the southernmost boundary between Iran and Iraq. The true sources of the conflict, however, were multifaceted. Saddam Hussein's main goal was to assert dominance over the Persian Gulf region, taking advantage of the power vacuum caused by the 1979 Iranian Revolution, in which Shah Mohammad Reza Pahlavi was overthrown by Shia forces loyal to Ayatollah Ruhollah Khomeini. The military, which had been intensely loyal to the Shah, was decimated by Khomeini, who had most senior military officers executed. Additionally, Khomeini's strained relationship with the United States now made it difficult for Iran to get spare parts for its equipment, most of which had been purchased by the Shah from the United States. This made Iran more vulnerable to attack. Other factors that influenced the onset and course of the war included the conflict between Sunnis and Shias (two Muslim sects), Arab versus Persian religious and ethnic disputes, disputed control of certain oil fields, and personal animosity between Hussein and Khomeini.

In the spring of 1980, the Iran-backed radical group Ad Dawah, which wanted to establish an Iranian-style Islamic government in Iraq, attempted to assassinate Iraqi foreign minister Tariq Aziz and minister of culture and information Latif Nayyif Jasim. In response, the Iraqis deported thousands of Shias to Iran. Saddam Hussein captured the leader of the Ad Dawah and his sister, executing them both in the summer of 1980.

Possession of the Shatt al Arab had been in dispute since the Peace Treaty of 1639 between the Persian and Ottoman Empires. Iraq claimed the 200-kilometer channel up to the Iranian shore as its territory, but Iran insisted that the thalweg, a line running down the middle of the waterway, was the official border. In the 1975 Algiers Agreement, a militarily weaker Iraq recognized the Iranian claim, but Saddam Hussein took advantage of perceived Iranian weakness after the fall of the Shah to press for total control. He also hoped to take the western Iranian region of Khuzestan, which had extensive oil fields.

Border skirmishes erupted on September 4, 1980, near Qasr-e Shirin, and Iraq launched a full invasion on September 23. The war continued to escalate to the point that, by 1985, both sides were launching air and missile strikes against their opponent's capitals.

Saddam Hussein had grossly underestimated the capability and resolve of the Iranians, who made impressive early gains. By 1982, the situation on the ground had grown desperate for Iraqi forces. Iraqi forces probably used the riot control agent CS, an extremely powerful tear gas, against Iranian troop concentrations that year. The first of ten documented chemical attacks in the war involving true casualty agents like mustard occurred during the Val Far II campaign near Haj Umran in August 1983. The Iraqis used mustard against an Iranian force on a mountaintop location, which had minimal impact because of both the altitude and unfavorable wind and weather conditions. Nonetheless, this marked the introduction of lethal CW agents into the war. By November 1983, Iraq had killed hundreds of Iranian forces with mustard.

As the war progressed, Iraqi CW tactics improved markedly. In an operation known as Khaybar I in February 1984, the Iraqis isolated the forward elements of an Iranian attacking force with mustard, cutting them off from food and ammunition supplies for days. According to Iranian claims, Iraq had conducted more than forty chemical attacks by this point. By mid-1984, there were credible reports of Iraqi use of a mustard variant known as dusty mustard, which impregnated solid particles with mustard agent to create a more militarily useful weapon. Iraq was also expanding its production of the nerve agents sarin and VX, with the former likely being used during the latter stages of the war. The largest documented attack was a February 1986 strike against al-Faw, in which mustard and tabun caused as many as 10,000 Iranian casualties.

The international response to these violations of international law (both Iran and Iraq were signatories to the Geneva Protocol of 1925, which prohibits the use of asphyxiating, poisonous, or other gases and of all analogous liquids, materials, or devices, as well as the use of bacteriological methods of warfare) was muted. In March 1984, United Nations secretary-general Javier Perez de Cuellar dispatched an international team to investigate the claims of CW by Iraq. They reported that chemical weapons were in fact being used, notably mustard and the nerve agent tabun. Despite this and despite continued pleas from Iran, little outrage ensued. The most dramatic step taken was the issuance of Security Council Resolution 582 on February 24, 1986, which merely "deplored" these violations of the Geneva Protocol.

In March 1986, de Cuellar, citing the report of four chemical warfare experts whom the UN had sent to Iran in February and March 1986, called on Baghdad to end its violation of the 1925 Geneva Protocol on the use of chemical weapons. The UN report had concluded, "Iraqi forces have used chemical warfare against Iranian forces"; the weapons used included both mustard and nerve gas. The report further stated: "the use of chemical weapons appear[ed] to be more extensive [in 1981] than in 1984" (de Cuellar, quoted in http://www.globalsecurity.org). Iraq denied using chemical weapons, but the evidence, in the form of many Iranian casualties severely injured by mustard agent and flown to European hospitals for treatment, was overwhelming. According to a British representative at the Conference on Disarmament in Geneva in July 1986, "Iraqi chemical warfare was responsible for about 10,000 casualties" (http://www.countrystudies.us).

Khomeini had reportedly ordered that no chemical weapons be used by Iranian forces because polluting the environment, even during a jihad ("holy war"), was a violation of the Koran. Nonetheless, in December 1986, Iran's former prime minister, Hussein Musavi, announced that Iran had developed "sophisticated chemical weapons." There are unconfirmed reports that Iranian forces used these weapons late in the war.

By 1988, the combination of CW deployment and imported military equipment from abroad had shifted the war in Iraq's favor. Iraq launched four major counteroffensives between April and August and won all of them. In April, Iraq used a chemical artillery barrage during an assault on Iranian positions on the Fao Peninsula.

In addition to employing them against the Iranians, Saddam Hussein used chemical weapons on his own citizens. One of the most notorious of these attacks was carried out in the north. Iraqi forces used a combination of mustard and nerve gas to kill approximately 5,000 civilians in the town of Halabja in March 1988. (*See* Halabja Incident.)

Iran finally agreed to a cease-fire pursuant to United Nations Security Council Resolution 958 on August 20, 1988. Ironically, in late 1990, Hussein readily gave up the minor gains he had achieved from these 8 years of fighting. In hopes of securing Iranian cooperation during the impending Gulf War that followed his annexation of Kuwait, he agreed to accept the terms of the 1975 treaty with Iran and to withdraw his troops from Iranian territory, as well as to exchange all prisoners of war. No formal agreement was signed, however, and both sides held thousands of POWs for many years. Several prisoner exchanges and releases occurred after 1988; the final exchange took place in 2003.

A complete tally of casualties suffered by both sides in the Iran-Iraq War will probably never be known. Iran calls the survivors of the chemical attacks living martyrs and claims that more than 60,000 soldiers were exposed to mustard and to the nerve agents sarin and tabun.

During the war, Iraq developed the ability to produce, store, and use chemical weapons, including H-series blister and G-series nerve agents. These were weaponized into rockets, artillery and mortar shells, aerial bombs, and warheads on the al-Hussein Scud missile variant. Iraq used Mig-23 fighter-attack aircraft to drop mustard- and tabun-filled 250-kilogram bombs and mustard-filled 500-kilogram bombs in random patterns from altitudes between 3,000 and 4,000 meters. They also deployed CW agents from Mi-8 HIP helicopters by generating an aerosol from two 1,000-liter spray tanks or by dropping 55-gallon drums filled with unknown agents (probably mustard) from altitudes of 3,000 to 4,000 feet.

Iran and Iraq also had nascent nuclear programs, and each took steps to prevent the other side from gaining nuclear weapons. Iran launched an unsuccessful attack on the Osirak nuclear reactor on September 30, 1980, in the first weeks of the war. (The facility was later destroyed by Israel in an air attack using F-16s on June 7, 1981. Israel justified this attack based on the fear that Iraq could develop a nuclear weapon to be used against Tel Aviv. Between 1984 and 1988, Iraq launched seven air attacks on the Iranian nuclear reactor at Bushehr during the Iran-Iraq War, ultimately destroying the facility.

—*James Joyner*

See also: Halabja Incident; Iran: Chemical and Biological Weapons Program; Iraq: Chemical and Biological Weapons Programs; United Nations Monitoring, Verification, and Inspection Commission (UNMOVIC)

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IRAQ: CHEMICAL AND BIOLOGICAL WEAPONS PROGRAMS

Iraq's chemical weapons capability has been known for some time, but information about its biological weapons program only emerged after 4 years of inspections, to much consternation within the world community. Iraq used chemical weapons during the Iran-Iraq War as a means of offsetting its numerical inferiority. It also used these weapons internally, most notably against the Iraqi Kurds, but it chose not to use these weapons during the 1991 Gulf War. Removing Iraq's alleged possession of weapons of mass destruction was the principal reason given for a U.S.-led coalition's invasion of Iraq in 2003.

History and Background

Passed in April 1991, UN Security Council Resolution 687 called for the complete destruction of Iraq's weapons of mass destruction, including all of its chemical and biological weapons and the infrastructure supporting them. A United Nations Special Commission (UNSCOM) was set up to oversee the destruction of these weapons and to report this to the UN Security Council. They remained in the country until the end of 1998, when they were withdrawn following lack of compliance by Iraq, and the United States and United Kingdom engaged in air operations to try to force greater cooperation from the Iraqi government. Under the terms of the UN resolution, the Iraqi authorities were supposed to provide the full details of Iraq's various programs and to fully support the UNSCOM inspections. Their actual help proved less than satisfactory.

The United Nations Monitoring, Verification, and Inspection Commission (UNMOVIC) replaced UNSCOM in 1999. In 2002, the UN Security Council passed Resolution 1441, giving Iraq a final chance to cooperate. The inspection mission returned to Iraq under the leadership of Hans Blix in late 2002, but it was again withdrawn in March 2003 when a U.S.-led coalition decided to use force against Iraq, arguing that Iraq had again failed to fully comply with the UN. A U.S.-led inspection mission looked for evidence of Iraqi weapons of mass destruction for months after the quick victory in April 2003, but little evidence was found.

Iraq began work on developing a chemical warfare capability during the early 1980s in response to the failure of its attacks on Iran. In the war that followed, the Iraqi regime gained a considerable amount of combat experience in the use of chemical weapons through their use against Iranian forces and in their use against Iraq's own Kurdish minority. Chemical weapons use became a regular part of Iraqi military operations, and these weapons were used for both strategic and tactical effect to offset Iraqi numerical inferiority. The Iraqi chemical arsenal fell into the three usual categories of CS gas, mustard, and nerve agents. In the latter category, tabun and sarin development has been verified, and there is evidence to suggest that other agents were also under development. During Operation Desert Storm, extensive damage was done to known Iraqi facilities from the air, and the extent of this was subsequently verified by UNSCOM. UNSCOM's efforts to uncover the full extent of the chemical warfare program and the remaining constituent parts, however, were hampered by Iraqi efforts at denial and deception. When UNSCOM withdrew in December 1998, it could not confirm that it had fulfilled its mandate of destroying the Iraqi program in full.

Kurds inspect an unexploded bomb—possibly filled with a CW agent—following a 1988 attack by Saddam Hussein's military. (Ed Kashi/Corbis)

Iraq's biological weapons program dates back to the early 1980s and was also developed in the context of the Iran-Iraq War. At this time, the regime considered using such weapons, fired from field artillery, for both strategic and tactical purposes. This effort did not succeed, however, until after the end of the Iran-Iraq War. Prior to Desert Storm, Iraq accelerated its production of anthrax and botulinum toxin. UNSCOM's Executive Chairman, Rolf Ekeus, was subsequently informed that authority had been delegated to local Iraqi commanders to use these agents in response to a massive attack on Baghdad. After Iraq's invasion of Kuwait in August 1990, a coalition-bombing raid destroyed Iraq's prototype aerial spray tanks.

Initially, Iraq claimed that it had no biological program, and for the first 4 years of inspections, little was discovered about the Iraqi BW program. The scope and extent of the various programs was only finally revealed when General Hussein Kamel Hasan defected from Iraq in August 1995. His debriefing revealed many details about various Iraqi programs and led to the subsequent modification of Iraqi denials. It also led the Iraqis to move steadily toward acknowledging the actual scale of the program as the inspectors discovered further details about the various operations. This proved to be a major shock for the international community, which had been close to accepting the Iraqi denials about its chemical and biological programs and to removing economic sanctions as a reward.

The Iraqis had developed a wide-ranging weapons program that was based on viruses, bacteria, and fungi in both their living form and their toxin derivatives. These weapons ranged from lethal agents and incapacitants to crop-attack agents, and their delivery means included field artillery, aircraft with tanks, and al-Hussein surface-to-surface missiles (modified Scuds). Subsequent investigations by UNSCOM confirmed that the Iraqis had produced at least 8,500 liters of anthrax and 19,000 liters of botulinum toxin, more than the Iraqis had ever admitted. In addition to these lethal agents, the Iraqi regime reported that it had made weapons out of 1,580 liters (of a total of 2,200 liters produced) of the incapacitant aflatoxin (derived from a fungus). In addition, the Iraqi regime admitted to having conducted research and development tests on a range of agents—*Clostridium perfringens;* ricin; and viruses including hemorrhagic conjunctivitis, rotavirus, and camel pox—for weapons purposes, plus field trials on an anticrop agent known as wheat cover smut.

Current Status

With the end of the war in Iraq, U.S.-led inspection teams are looking to destroy Iraq's chemical and weapons programs once and for all. Little has been found, but the inspections continue.

—*Andrew M. Dorman*

See also: Halabja Incident; Iran: Chemical and Biological Weapons Programs; Iran-Iraq War; United Nations Monitoring, Verification, and Inspection Commission (UNMOVIC)

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J

JAPAN AND WMD

Twenty-first century Japan does not possess any weapons of mass destruction (WMD), including nuclear, biological, or chemical weapons. The Japanese military, however, employed chemical and biological weapons against China during World War II. Substantial evidence suggests that Japan also pursued a nuclear weapons research program until 1945 but did not make very much progress.

Japan also has the unfortunate distinction of being the target for chemical terrorism involving nerve agent (sarin). In 1994–1995, following the orders of their guru Shoko Asahara, operatives within the new age cult called Aum Shinrikyo used improvised chemical weapons against the Japanese authorities, killing about 20 people and injuring more than 1,000.

Japan's Nuclear Legacy

Japan is unique in being the only country to be subjected to atomic bombing. As a means to help shorten the Pacific War, on August 6, 1945, the United States dropped a uranium-235 nuclear device on Hiroshima; three days later, it dropped a plutonium device on Nagasaki. Out of a population of 250,000 in Hiroshima, at least 45,000 people died on August 6, many from the thermal and blast effects produced by the weapon. Nearly 20,000 died during the following 4 months due to their injuries, which included radiation sickness. In Nagasaki, some 22,000 people died from the initial blast, and another 17,000 succumbed to their injuries over the subsequent 4 months. There may have been many more who perished as a result of these bombings but who, for various reasons, were not recorded.

The legacy of the atomic blasts included 63 extra cases of leukemia among the 92,000 atomic bomb survivors (one would normally expect 21 cases in a normal population). As for genetic abnormalities among those who survived and their progeny, studies have shown that these are surprisingly rare. A recent survey concluded: "the expected increase of genetic damage in the atomic-bomb survivors is so low that it would not be detectable within the larger spontaneous incidence. In screening . . .the blood of 27,000 children of atomic-bomb survivors, only two children presented mutations that might be related to the radiation exposure of the parents" (Walden, p. 202).

Japan's Historical Use of Chemical and Biological Weapons

During Japan's colonization of Taiwan, brutal pacification campaigns were waged against local indigenous groups, particularly during the years 1910–1914. Local tribes revolted against the Japanese, including those in Wushe, a mountainous area in central Taiwan. Local historians agree that, during the infamous Wushe incident of 1930, Japan used chemical warfare (CW) agents to crush the rebellion led by tribal leader Mona Rudo. (Japan had begun production of CW agents in 1928 on Okunoshima Island.) During the 1930 uprising, 134 Japanese people were killed by resistance guerillas. In addition to employing co-opted tribe members as bounty hunters, Japan crushed the rebellion using "Green canister" shells (chloracetophenone, or CN). In the end, 644 of the indigenous people were dead, representing about half of the indigenous community in Wushe. This particular engagement may have been part of the experimental testing with CW conducted by the Japanese on Taiwan between 1930 and 1941.

Starting in 1937, the Japanese army employed a wide range of CW agents during its invasion of China. Quoting an "authoritative Soviet source," a book written by Chinese military specialists in CBW

Japanese technicians dispose of World War II–era abandoned chemical weapons on China's soil. (China Photo/Reuters/Corbis)

defense claims that "during its war in China, the Japanese army had prepared 25 percent of their artillery shells to be chemical munitions, while 30 percent of its aerial ordnance were chemical bombs" (Wang and Yang, p. 97). According to these same authors, "Fascist Japan used CW over 2,000 times, causing 90,000 casualties" (Wang and Yang, p. 102). In 1991, the Chinese People's Liberation Army (CPLA) claimed that more than 80,000 people were killed in approximately 2,000 chemical attacks by the Japanese army during World War II. (It is possible that translators have confused casualties with fatalities, which might explain the discrepancies.) Yet another source tallies 10,000 deaths and 80,000 wounded from Japanese chemical weapons. More precise (if not accurate) statistics record that from July 18, 1937 to May 8, 1945, Japan carried out 1,059 chemical attacks in China, including the use of CW agents diphenylchloroarsine, diphenylcyanoarsine, chloroacetophenone, chloropicrin, hydrogen cyanide, phosgene, mustard, and lewisite. A 1938 report from the Red Cross, signed by five physicians on the scene, reported that at Xuzhou "a large number of wounded soldiers was rushed to the hospital. Among them they found several cases showing generalized skin blisters and lesions resembling more or less those caused by smallpox . . . photographed evidence is available" (Hoo, p. 1).

Although it is difficult to evaluate the extent of Japanese use of chemical weapons in China, it would appear that mainland sources exaggerate the overall importance of CW to explain Japan's success against Nationalist (Kuomintang) armies. Japanese soldiers, especially those serving in China, were highly disciplined and ruthless, operating under a well organized command structure. The latter qualities were not to be found among the Chinese resistance, already fractured by a rivalry between the KMT and Chinese Communist Party forces led by Chiang Kai-Shek and Mao Zedong. Although it certainly assisted the Japanese forces in certain engagements, it is difficult to conclude that CW played a decisive role in the Sino-Japanese war of 1937–1945.

Biological Warfare in China

During the years 1931–1945, Japan pursued a BW program and conducted biological weapon field tests against Chinese military and civilian targets. Much has been written about the gruesome experiments conducted by General Ishii Shiro and his Unit 731, and by other specialized detachments in China during World War II (*see* Unit 731). Sheldon Harris has compiled the following numbers of casualties that resulted from Japanese BW activity in China, although there are many instances in which casualties can only be estimated.

Table J-1: Japanese BW Operations in China, 1937–1942

Ningbo, summer 1940, October–November 1940	99 deaths from plague reported
Changteh City, Hunan Province, spring–summer, November 4, 1941	400–500 deaths; minor epidemic resulted, +24 fatalities
Chekiang Campain, Yushan, Kinhwa, Futsing, summer 1942	Chinese casualties evaluated as high, but attack boomeranged, causing numerous Japanese casualties (estimated to be as high as 10,000)

Kojima Takeo, a captain in the Japanese Imperial Army, reported that "about twenty thousand Chinese died from cholera" as a result of Unit 731 field operations (Gold, p. 249). Total Chinese deaths due to Japanese BW—that is, actual weaponized use in the field (not including the 3,000-plus Chinese, Korean, and other prisoners of war who died from Japanese BW military experiments)—could start at 21,000. Perhaps not unexpectedly, Chinese estimates of deaths caused by Japanese BW activities are much greater. According to one Chinese source, "During Japan's invasion of China, BW was carried out among twenty or more provinces and cities in China, causing more than 200,000 casualties among the Chinese people" (Liu, p. 368). Other Japanese and Chinese scholars have since come to the conclusion that "at least 270,000 Chinese soldiers and civilians were killed as a result of Japanese germ warfare between 1933 and 1945" (Shi, 2001). However, no information to date can support such a figure, nor is it likely that Japanese BW activities can be definitively linked to every occurrence of plague or other infectious diseases in China at that time. Plague, for example, has been endemic to China since 1894, and during wartime it is common for public hygiene to collapse completely, leading to the rapid spread of infectious disease.

—*Claudine McCarthy*

See also: Aum Shinrikyo; Unit 731; World War II: Biological Weapons; World War II: Chemical Weapons; Wushe Incident

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JOHNSTON ATOLL

Johnston Atoll, a group of four islands located 825 miles southwest of Hawaii, played a key role in the U.S. nuclear, biological, and chemical weapons programs. An unincorporated U.S. territory, the islands were first used for atmospheric nuclear testing in the 1950s. Then, beginning in 1964, a series of biological tests was conducted offshore of the islands to measure the susceptibility of rhesus monkeys located on barges to biological agents released by aircraft overhead. Most significantly, the United States moved chemical weapons that it had previously stored abroad to the atoll, where they were kept until their destruction was completed in November 2000.

In 1969, an accidental leak of VX nerve agent stored by the United States on the island of Okinawa injured twenty-three U.S. military personnel and one civilian, leading the Japanese government to request the removal of the weapons (*see* V-Agents). Plans were made to move the stockpile to Umatilla Army Depot in Oregon. Before the transfer was completed, however, Congress passed Public Law 91-672, which prohibited the army from relocating chemical weapons stored overseas to anywhere in the continental United States. Instead, in a 1971 effort designated Operation Red Hat, the weapons from Okinawa were transported to Johnston Island, one of the islands comprising the Johnston Atoll. Almost 20 years later, following the conclusion of a bilateral chemical weapons destruction agreement with the Soviet Union, the United States in 1990 relocated another cache of weapons from Germany to Johnston Island in Operation Steel Box. Before actual destruction took place in the 1990s, 6.6 percent of the original U.S. chemical weapons stockpile was stored on the atoll.

Built in 1990, the Johnston Atoll Chemical Agent Disposal System (JACADS) was the first U.S. chemical weapon destruction facility to become operational (*see* Demilitarization of Chemical and Biological Agents). Using incineration technology, the facility destroyed more than 400,000 projectiles, mortars, bombs, rockets, and mines containing mustard, sarin, and VX (*see* Mustard, Sarin, and V-Agents). Eight months after the final destruction of the weapons and agent was completed, the U.S. Army Chemical Activity, Pacific, the unit responsible for the storage, security, and transport of chemical munitions and agent on Johnston Atoll—was deactivated.

The army's plan to dismantle JACADS was approved by the Environmental Protection Agency in September 2002. The plan encompasses the disassembly of the JACADS facility, the treatment of waste generated by the weapons destruction, and cleanup of the island. Relying on human health and ecological risk assessments, sampling and analysis, and quality assurance methods, the U.S. Army is required to certify that the atoll is safe before they depart. Once that assurance has been provided, the atoll will transfer into the custody of the U.S. Fish and Wildlife Service. Johnston Atoll, which was designated a National Wildlife Refuge in 1926, will then become a bird sanctuary.

—Claudine McCarthy

See also: Demilitarization of Chemical and Biological Agents; United States: Chemical and Biological Weapons Programs

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K

KAFFA, SIEGE OF

The Mongol siege of the Crimean city of Kaffa in 1346 is often cited as one of the first recorded incidents of biological warfare—and perhaps even the cause of the spread of bubonic plague to Europe.

The city of Kaffa (or Caffa, now Feodosija, Ukraine), established in 1266 by agreement between the Mongols on the Black Sea and the Genoese, was an important trading hub between Genoa and the Far East. In 1289, the city fell under the suzerainty of the Khan (Toqtai) of the Golden Horde. The relationship between the Genoese and the Khan, however, was an uneasy one. Kaffa was first besieged in 1308 after the reported displeasure of Khan Toqtai over Genoese trading in Turkic slaves. (The sale of these slaves to the Marmelake Sultanate in Egypt reportedly upset the Khan by depriving him of an important source of foot soldiers for his own army.) The Genoese set fire to Kaffa and fled. After Toqtai's death, Khan Uzbeg allowed the Genoese to rebuild their trading colony in 1312.

In 1343, after a brawl between Christian locals and Muslims in the Italian enclave of Tana inflamed the ire of Khan Janibeg, the Italians fled from Tana to Kaffa, bringing the Khan's army to the gates of Kaffa behind them to besiege the city. In February 1344, the Italians managed to break the siege after killing 15,000 of the Khan's Tartars and destroying their siege machines. Janibeg renewed the siege the following year, but the residents of Kaffa were able to maintain their position because they retained access by sea to supplies.

In 1346, the Khan's army besieging Kaffa suffered a natural outbreak of plague. The Tartars catapulted the plague-infected corpses of their dead comrades over the city walls. According to one historical account, the Tartars' tactic finally broke the 3-year stalemate; the Genoese were crippled by the plague and fled Kaffa by sea—taking the disease to Europe with them.

The most contemporaneous account of the siege was written by Gabriele de' Mussi, a notary of the town of Piacenza, north of Genoa. There is some debate as to whether de' Mussi witnessed the events at Kaffa. Written in 1348 or 1349, the account describes the "mysterious illness" that struck the Tartar army besieging Kaffa. De' Mussi recounts how the Tartars, desperate from the devastation of the disease on their army, thought to kill the inhabitants of Kaffa with the stench of their diseased dead. According to the de' Mussi account, the people of Kaffa had no hope once the air and water had been contaminated, and only one in 1,000 was able to flee the city. Those that did flee took the plague with them as they left.

De' Mussi's account suggests that not only did the Tartars deliberately hurl their diseased dead over the city walls of Kaffa with the intent to kill their enemies, but those escaping Kaffa brought the disease into the ports of Europe. The disease was most likely brought within the walls of Kaffa through flea-infested rodents from the Tartar camps, or possibly through the transmission of the disease from direct contact with infectious body fluids from the Tartar dead.

Most scholars believe that the Genoans brought the plague with them to Naples, from where it then spread throughout Europe. Others have recently suggested that although the use of plague corpses against Kaffa was a true act of biological warfare, the siege had no significant impact on the spread of the Black Death through Europe. As Wheelis suggests, Kaffa was certainly not the only Tartar port that could have transmitted plague into European ports. Wheelis further argues that the rate and pattern of plague transmission suggests that it took 1 year to spread the plague into different European ports.

Though Kaffa may not have been the precise source of the Black Death that spread into Europe, the use of infected cadavers against its besieged inhabitants remains one of the most important instances of the intentional use of disease in warfare.

—*Jennifer Lasecki*

See also: Biological Warfare; Plague; Vector

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KOREAN WAR

The Korean conflict began as North Korean troops, aided by the former Soviet Union, launched an artillery barrage against U.S.-backed South Korea on June 25, 1950, in an attempt to unify the peninsula under Communist rule. Under United Nations command, United States and Republic of (South) Korea (ROK) forces managed to push the North Korean army back, and UN forces were able to get across North Korea as far as the Chinese border that winter. Faced with the prospect of losing Korea to the Western "Imperialists," Mao Zedong ordered a counterattack. Fortunes turned once again, as Chinese volunteer forces crossed the (now frozen) Yalu River and nearly overwhelmed UN forces. Finally, the belligerents reached a stalemate near the thirty-eighth parallel, resulting in *status quo antebellum.* Some 130,000 U.S. military personnel were killed or wounded by time of the Armistice in 1953. Perhaps as many as 2 to 3 million Koreans and 1 million (or more) Chinese people were killed during the conflict.

Allegations of Chemical Warfare

The Chinese government and military apparatus claim that the United States—presumably with UN connivance—used chemical weapons against North Korean and Chinese People's Volunteer Forces (CPVF) during the conflict. These allegations peaked in 1953 and were proven false, but the belief persists, at least within mainland China, that chemical weapons were used by UN forces. For example, a Chinese book on chemical weapons published in 1997 states that during the Korean War, the U.S. military used chemical weapons against the Sino-Korean forces on more than 200 occasions, and the book lists the following CW agents by name: mustard, cyanide (presumably HCN), chloropicrin, and chloroacetophenone (CN).

China first made formal chemical weapons charges during the Korean War on March 5, 1951. The Report on U.S. Crimes in Korea, compiled by the Communist front organization International Association of Democratic Lawyers, claimed that the United States used chemical weapons between May 6, 1951, and January 9, 1952. The UN ambassador from the former Soviet Union, Jakob Malik, repeated similar charges in February 1952. However, when the International Scientific Commission (a group of Sinophilic scientists, leftists, Marxists, and otherwise Maoist fellow travelers [communist sympathizers]) reported on the BW allegations (see below) in 1952, no mention was made of chemical weapons being used in Korea or China. Furthermore, in a 1998 book alleging that the United States conducted BW during the Korean conflict, authors Stephen Endicott and Edward Hagerman make no mention of chemical weapons being used (aside from some peripheral references to U.S. CW agents and chemical/biological warfare policy).

Perhaps the most dramatic testimony that undermined the Chinese allegations of CW during the Korean War is found in the Soviet archives. Lt. Gen. V. N. Razuvaev, former Soviet ambassador to North Korea and military advisor for the Korean People's Army, wrote the following to Levrenti Beria (Stalin's infamous henchman and chief of espionage) on April 18, 1953:

> The Chinese . . .wrote that the Americans were using poison gas in the course of the [Korean] war. However, my examinations into this question did not give positive results. For example, on April 10, 1953, the general commanding the Eastern Front reported to Kim Il Sung that 10–12 persons were poisoned in a tunnel by an American chemical missile. Our investigation established that these deaths were caused by poisoning from carbonic acid gas [i.e., CO_2] [released into] the tunnel,

The United States used napalm with great effect against communist forces during the Korean War (1950–1953). (Corbis)

> which had no ventilation, after the explosion of an ordinary large caliber shell. (Razuvaev, quoted in Weathersby, http://wwics.si.edu)

In retrospect, the Russian archives explain best why Chinese military leaders could have believed that the United Nations armies were using chemical warfare. The CPVF was torn apart by U.S. artillery and air strikes. (Even Mao Zedong's eldest son, Mao Anying, was killed during a U.S. napalm strike.) In addition to the devastating effects of these attacks, resultant off-gases from bombardments were no doubt responsible for respiratory distress and pulmonary edema among Chinese soldiers, symptoms that are largely indistinguishable from those caused by lung irritants found in chemical weaponry. For the Chinese leadership (namely Mao Zedong and Zhou Enlai), interested in propaganda to give a sense of being the victim of an "imperialist aggressor," it made practical sense to blame the deaths of the ill-equipped CPVF soldiers on phantom chemical weapons used by the "imperialists."

Allegations of Biological Warfare

In March 1951, Peking radio charged that the United Nations Command was manufacturing biological weapons for use against North Korea. In May of that same year, the North Korean Minister of Foreign Affairs protested to the United Nations that the United States had attacked Pyongyang with smallpox. Almost a year later, on February 22, 1952, North Korea made more detailed charges, claiming:

> The American imperialist invaders, since January 23 this year [1952], have been systematically scattering large quantities of bacteria-carrying insects by aircraft in order to disseminate infectious diseases over our front line positions and rear. Bacteriological tests show that these insects scattered by the aggressors on the positions of our troops and in our rear are infected with plague, cholera and the germs of other infectious diseases. This is

> irrefutable proof that the enemy is employing bacteria on a large scale and in a well-planned manner to slaughter the men of the [Korean] People's Army, the Chinese People's Volunteers, and peaceful Korean civilians. (van Courtland Moon, p. 55)

In response to these charges, General Matthew B. Ridgeway addressed the United States Congress, saying "no element of the United Nations Command has employed either germ or gas warfare in any form at any time" (Leitenberg, http://wwics.si.edu).

Nevertheless, by dint of their own writings and public pronouncements, the Chinese government still appears to believe that the United States employed biological weapons during the Korean War. Real Japanese BW atrocities that occurred in China during the 1930s and 1940s make these dubious Korean War allegations appear reasonable. During the first half of 1951, when the allegations first emerged, the Chinese media often referred to Japanese biological weaponeers, and on April 30, 1951, they even claimed, "the American forces are using Chinese People's Volunteers as guinea pigs for their bacteriological experiments" (Leitenberg, p. 174).

The United States has refuted the allegations concerning its use of chemical and biological weapons during the Korean War. Despite the paucity of real evidence to support such a claim, however, it would appear that these charges are etched upon the collective consciousness of the Chinese leadership. Unfortunately, Western collaborators with the myth of BW in the Korean War are often cited by the Chinese as further proof that the United States engaged in chemical and biological warfare against the Chinese.

—Eric A. Croddy

See also: North Korea: Chemical and Biological Weapons Programs; South Korea: Chemical and Biological Weapons Programs; United States: Chemical and Biological Weapons Programs

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L

LATE BLIGHT OF POTATO FUNGUS (*PHYTOPHTHORA INFESTANS*)

Late blight of potato is caused by the fungus *Phytophthora infestans,* which was most likely responsible for the Irish potato famine of 1845–1847. Isolated cases of potato crops with this fungus are still common around the world, and, once started, the plant disease is very expensive to treat. Lesions that form on infected plants can produce some 300,000 fungal spores each day, and when conditions are right, spores of this fungus (sporangia) can be spread for miles by flowing water or by the wind. Because of the importance of potatoes as a food staple and agricultural commodity, the potential consequences of an attack using this fungus in agroterrorism could be enormous. At the same time, experimental data show that it would be difficult to replicate natural disasters such as the Irish potato famine using deliberate introduction of the fungus to potato crops. Still, this fungus is among several agents of concern when considering food safety and potential vulnerabilities to bioterrorism or state-sponsored biological warfare (BW).

Many Americans and Canadians of Irish ancestry can trace their family histories back to the 1845–1847 Irish potato famine (also known as the Black '47). When, in 1845, Irish potatoes became infected with the *Phytophthora infestans* fungus, an entire crop of tubers was destroyed—as was a great source of nourishment. The unfortunate confluence of bad weather and colonial oppression exacerbated the crisis as the disease continued to affect potato crops throughout Ireland. Some 1.5 million people died of starvation, and a like number left the country, many choosing to emigrate to the United States.

During the mid-1800s, the great tragedy in Ireland piqued the interest of Dr. Miles J. Berkeley, who believed that a fungus was responsible for the potato blight. However, he could not find sufficient proof to support his notion, because it was still possible that the fungus only grew on the potato after the fact, and was not necessarily the original cause of death of the plant. In 1861, the German researcher Anton De Bary conducted his own experiments with potatoes and was able to conclude that, indeed, a parasitic fungus was responsible. He named it *Phytophthora infestans*—"the terrible plant destroyer." De Bary's work established an important foundation for the study of plant diseases as a discipline.

Later, in the 1900s, potato blight would haunt Germany during World War I. On the heels of spectacular potato harvests early in the Great War, in 1916, potatoes were soon rotting in the fields and creating a fulsome stench in German supply houses. *Phytophthora infestans* struck at a most inopportune moment for Germany. The subsequent loss of potatoes could have been averted were it not for the fact that copper, needed during the war for shell casings, electrical wire, and other war-related materiel, was therefore made unavailable for production of copper sulfate, a well-known antifungal used at that time. Seven hundred thousand Germans starved to death in this famine, and this may have contributed to Germany's defeat.

During World War II, French and U.S. officials noted how economically dependent the Axis powers were on potatoes as a staple food crop, particularly the German and Japanese reliance on sweet potatoes. During researches into potential BW agents in World War II, *Phytophthora infestans* was seen as a potentially effective weapon. Code named OL, late blight of potato was researched at the Main Agricultural Experiment Station in Orono, Maine. One method of delivery devised for potato blight involved the use of navy beans and specially made pellets to use as carriers to deliver the fungus to the target. Producing and storing this fungus in large quantities proved extremely difficult. Eventually, though, the United States developed a standardized arsenal of anticrop agents and continued its research in late blight of potato as part of its now-defunct biological weapons program (formally ended in 1972).

Today, unlike in nineteenth-century Ireland, industrialized countries do not depend upon a single source of calories. Because modern agriculture can produce an abundant and diversified food supply, it is unlikely that late blight of potato would cause severe hardship for most countries, and it would certainly not lead to starvation. Furthermore, genetically modified potatoes are being researched to develop a resistance to this fungus. This research holds the promise of helping to avoid both natural and deliberate outbreaks of late blight in the future. The economies of underdeveloped countries, however, may be more vulnerable to natural or possibly deliberate attacks on their food supplies.

—Eric A. Croddy

See also: Agroterrorism (Agricultural Biological Warfare); Mycotoxins

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LIBYA AND WMD

Since his successful coup against King Idris in September 1969, Colonel Mohamar Qaddafi has been the unchallenged leader of Libya. During Qaddafi's fulsome regime, the North African nation has gained pariah status among the nations of the world. Events in late 2003, however, may have changed this trend. In a startling announcement made on December 19, 2003, Qaddafi announced that his government will forgo its weapons of mass destruction (WMD) programs, presumably meaning activities related to the production of chemical, biological, or nuclear weapons.

During the 1970s and 1980s, Libya supported terrorist organizations such as the Irish Republican Army and the Palestinian Liberation Organization. Libya also was implicated in the bombing of a Berlin nightclub in 1986, intended to target U.S. military personnel. This attack killed two U.S. soldiers and one civilian, while injuring more than 250 people. Having determined that Libya was directly connected with the bombing, the United States responded in retaliation with an air raid against Tripoli. The Libyan government has also admitted that it was responsible for the downing of Pan Am flight 103, a civilian jetliner, over Lockerbie, Scotland, in 1988, and it has since paid billions of dollars to the victims' families in compensation.

During most of Qaddafi's rule, Libya has been considered a "rogue nation," developing chemical weapons as well as acquiring delivery systems such as the Scud B and C missiles. Although a member of the Nuclear Nonproliferation Treaty (NPT) and subject to International Atomic Energy Agency inspections, Libya may have as many as eleven nuclear-related facilities rather than the four that have been officially declared. An unconfirmed report from the 1970s alleged that Libya attempted—but ultimately failed—to purchase a nuclear device from China. Thirty years later, the scope of Libya's nuclear program is still unknown.

Some reports suggest that Libya may have pursued biological weapons development. There also are rumors that the former director of South African biological weapon activities, Dr. Wouter Basson, covertly assisted Libya in this pursuit during the mid-1990s.

Libyan Chemical Weapons

Countries such as Egypt and the former East Germany may have shipped chemical munitions to Libya during the 1970s. In its war with neighboring Chad, Libyan troops reportedly used chemical warfare (CW) agents in the late 1980s. As a response, the United States shipped some 2,000 protective masks to Chad. During this same time frame, Libya established a suspected CW agent production facility at Rabta (Pharma 150) using technology acquired from West Germany. However, the estimated quantity of CW agent produced at this facility was not a large figure, perhaps 100 tons.

In the early 1990s, after the United States hinted that a preemptive strike against Pharma 150 was possible, Libyan officials decided to build an underground chemical facility. Built inside of a granite mountain, the Tarhunah facility was described by the U.S. Central Intelligence Agency as the "world's

Artist's conception of the suspected Libyan chemical facility in Tarhunah. (Corbis/Sygma)

largest underground chemical weapons plant" (Rosenthal, p. A23). Qaddafi later announced that he would stop construction at Tarhunah after a diplomatic consultation with Egyptian president Hosni Mubarak. In the summer of 1996, U.S. Department of Defense (DoD) sources confirmed that the site appeared dormant. In March 1997, however, Israeli sources reported that construction at Tarhunah had resumed.

In 2003, Libya reportedly engaged in low-level negotiations with the United States and Great Britain over its WMD programs. According to published accounts, U.S. and British intelligence diverted a ship purported to have been carrying gas centrifuges to Libya in September 2003. On December 19, Libya announced that it would end its WMD programs and would subject itself to international inspections, which would include the full disclosure of its nuclear fuel cycle. Libya's decision was probably influenced by the interdiction of the dual-use gas centrifuges, as well as the success of the U.S. coalition's invasion of Iraq, which was ostensibly undertaken to rid Iraq of its WMD programs and of its dictator.

It is uncertain whether Qaddafi's recent turnaround with regard to WMD will result in a better understanding of Libya's chemical, biological, and nuclear weapons activities, or whether Qaddafi is fundamentally changing the course of his national policies. Qaddafi's constructive reengagement with the West may be signaling an end to Libya's marginalization in the global polity.

—Eric A. Croddy

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LINE SOURCE

A moving device or a linear series of stationary devices that disperse chemical, biological, or radiological (CBR) agents is known as a line source. (Two other common classifications of sources are point and area sources.) Typically, a line source constitutes a moving platform such as an aircraft, boat, or ground vehicle, which discharges a CBR agent as it moves. For example, between 1935 and 1936, Italian forces used aircraft to spray chemical agents, mainly mustard, on enemy forces in Ethiopia.

A moving platform, however, is not required for a line source. On April 22, 1915, outside the city of Ypres, Belgium, the Germans released chlorine gas from more than 5,000 cylinders, forming a 5-mile-wide toxic cloud. This cloud would best be classified as a line source despite the fact that it was produced from more than 5,000 point sources (*see* Point Source). As another example, artillery guns can deliver shells containing CBR materials along a wide front perpendicular to the wind direction. The cloud released from such an artillery barrage would be best modeled as a line source, although the source of the contamination is stationary. The classification of a source (as point, line, or area) depends on the spatial and directional characteristics of CBR contamination. This information is also used to develop vulnerability assessments and prepare emergency response plans.

An agent released into the atmosphere is affected by meteorological conditions: temperature, pressure, wind direction, and wind velocity. It is most effective to employ chemical weapons during an inversion, when the air temperature increases with altitude and the contaminant is therefore held close to the ground. Inversions normally occur at dawn, dusk, or night. Atmospheric releases of agents occur as either a continuous plume or an instantaneous discharge (puff). If the total duration of the release is much less than the transport time between the source and the downwind receptor, then the cloud is best described as an instantaneous release. Because the total amount of agent to be delivered is of limited quantity, the time of actual release will necessarily be of short duration. Line sources are most effective when the line along which they are employed is perpendicular to the wind. When employed in this way, a line source can contaminate a relatively large area, compared to a point source release of the same quantity and concentration of CBR agent.

Recent trends in research and development have focused on improving wide-area, long-range, standoff (that is, at considerable distance up to 50 km), and remote agent detection systems that can increase early warning time and assist in consequence management in the event of CBW. In the event of a line or point source delivery, it is possible that adequate standoff detection systems will provide adequate intelligence for authorities to take appropriate defensive measures—before the public is exposed to toxic or infectious aerosolized agents.

—Robert Sobeski

See also: Aerosol; Biological Warfare; Chemical Warfare; Inversion; Point Source

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LIVENS PROJECTOR

Also referred to as an "8-inch chemical drum," the Livens Projector was one of the more effective means of delivering chemical warfare (CW) agents during World War I. Essentially, the Livens fired a large chemical artillery shell, the Livens projectile being launched from mortars set in the ground. Standing about 2 feet in height and about 7.5 inches in diameter, the Livens shell had a total weight (including the gas or explosive inside) of 60 pounds. The mortar was set into the ground at a 45 degree angle so as to maximize the range.

The device was named after the colorful and brilliant inventor Major William Howard Livens of the British army, whose wartime forays into the invention of early flamethrowers and other devices are the subject of legend. (Livens's superior officer, Foulkes, once wrote that, although he was duly impressed with the young man's ingenuity and enthusiasm for his work, Livens had "little use for factors of safety or correct official procedure" [quoted in Richter, p. 150].) A fellow officer, Harry Strange, collaborated with Livens on the overall design. The inspiration for the Livens Projector came from the use of oil cans to make Molotov cocktails. At first, the incendiary form of the early Livens Projector fired canisters filled with oil and were launched using modular sack charges. By adding additional explosives in measured amounts, as in traditional artillery, one could control the overall distance. But it soon became apparent that the Livens Projector had the potential for offensive CW applications.

Following the chlorine gas attack at Ypres in 1915, the Livens Projector was rigged to launch chemical agents. Its design could launch large volleys of chemical shells in rapid succession, making it the most efficient means of deploying gas during the war. The Livens Projector was particularly useful in launching phosgene canisters at distances of 1,700 meters, and German troops reported that it had significant impact on the battlefield: "The enemy has combined in this new process the advantages of gas clouds and gas shells. The density is equal to that of gas clouds, and the surprise effect of shell fire is also obtained. . . . Our losses have been serious up to now, as he has succeeded, in the majority of cases, in surprising us, and masks have often been put on too late" (Spiers, p. 25).

The Livens Projector also had its disadvantages. Although the main part of the firing base mortar was hidden by earth and relatively easy to conceal, the system could only be fired once.

Occasionally, Livens Projectors turn up in old sites among abandoned and obsolete munitions. In 1993, a construction worker discovered a Livens projectile at a site near American University, Washington, D.C., prompting a full-scale evacuation in Spring Valley, Washington, D.C. Some of the 200-

millimeter Livens projectiles found in 1993–1994 still contained some chemical agent. In April 1999, some children found a Livens projectile at Fort Ord, Monterey, California. Fortunately, this Projector the children found was originally used only for training and contained no explosives or toxic chemicals.

—Eric A. Croddy

See also: Chemical and Biological Munitions and Military Operations; Choking Agents (Asphyxiants); World War I

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LYOPHILIZATION

Having been used for many years in biotechnology research and related applications, lyophilization—essentially, freeze-drying—can be utilized for research and development of biological warfare (BW) agents. Because one of the major obstacles to keeping biological agents in storage over long periods of time is the issue of water content, a way is needed to keep these agents stable by removing water without destroying the organism, destroying its enzymes, or denaturing proteins. By reducing the amount of water contained in biological materials through freeze-drying, the resultant product can remain in storage for long periods of time without losing biological activity.

When it comes to dealing with BW applications, essentially the problem is how to produce a storable agent that also remains viable—thus, the relevance of lyophilization in biological weapons development and production. Furthermore, once the given agent has been freeze-dried, further processing (such as milling) can be performed to create BW agents that can be aerosolized. Work conducted for the U.S. biological weapons program in the 1940s found that freeze-dried organisms could remain viable for extended periods of time. In this case, simulants—inocuous agents used to simulate the behavior of BW agents in this case—such as *Serratia marcescens* could be produced in dense liquid suspensions and then lyophilized to survive up to several weeks without losing very much in the way of viability. Similar techniques were utilized by both the United States and the former Soviet Union during the heyday of the Cold War in their respective biological weapons programs.

A lyophilizer is a dual-use item that has both civilian use and potential military use in developing biological weapons. As this technology is used widely for civilian pharmaceutical and other research, using this technology would not necessarily raise particular suspicions concerning possible offensive BW activities. Other information would be necessary to indicate that possession or use of a lyophilizer meant there was illicit biological weapons research at work. One significant factor to consider would be the overall production capacity of the equipment, as full-fledged BW programs would require more than the small quantities of material produced in single batches in laboratory settings. (During World War II, for example, the United States used lyophilizing equipment in its nascent BW program that could handle up to 2.5 liters or about 2.5 kilograms of material in a single batch.) Another consideration in determining the possibility of BW use would be the type of organism or biological material being processed, as well as the general scope of the activity.

—Eric A. Croddy

See also: Dual-Use

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M

MARBURG VIRUS

Marburg virus is named after the German city in which a laboratory outbreak of hemorrhagic fever occurred among the staff of a hospital in 1967, during which 31 people became infected and nine died. Marburg virus is a member of the Filoviridae family, the other known member being Ebola virus. According to Ken Alibek, former deputy of the Soviet Biopreparat biological weapons program, the Soviet Union had planned to weaponize Marburg just before Boris Yeltsin rose to power in 1991. It is unknown whether Russian scientists continued research with Marburg with the aim of using it as a biological weapon during the 1990s.

—Eric A. Croddy

See also: Biopreparat; Hemorrhagic Fevers

MELIOIDOSIS

Melioidosis is an infectious disease of humans and animals caused by the free-living (survives on its own) bacterium—once thought to be parasitic—*Burkholderia pseudomallei,* a natural inhabitant of soil and water in rice-growing regions of the world. The disease is concentrated in parts of northern Australia and southeast Asia, especially Thailand, Malaysia, and Singapore. Humans are usually infected by direct inoculation of the organism through breaks in the skin, less often by inhalation or ingestion of dust or aerosolized polluted water, and rarely by contact with infected animals or other humans.

The bacterium causing melioidosis was first isolated in 1912 from a morphine addict in Rangoon, Myanmar. *Burkholderia* (formerly *Pseudomonas*) *pseudomallei* is an aerobic (thrives in oxygenated environments) gram-negative (does not absorb gram's stain) rod-shaped bacterium. The disease-causing propensity, or virulence, of the organism is largely due to its ability to evade host defense mechanisms and to survive inside macrophages, the cells that defend the body from invaders, and other phagocytic cells of the host. Melioidosis, also known as glanders-like disease, is of current interest because *B. pseudomallei* has been studied in the past by bioweapons developers in the United States and other countries. *B. pseudomallei* could still potentially be developed as a weapon because it is relatively easy to grow, has prolonged survival in the environment, is infectious by aerosol, and has a high capacity to cause severe illness and death.

Melioidosis is endemic (occurring naturally and consistently) in tropical and subtropical regions of the world and is a common infectious hazard for rice farmers, travelers, and military troops. During the rainy season, the bacteria, normally associated with plant roots, rise from the clay layers of the Earth into the surface waters and multiply. Humans and animals are most vulnerable to acquiring infection in endemic areas during the monsoonal wet season. A few isolated cases diagnosed in the Western Hemisphere have been imported from the tropics by immigrants, travelers, and Vietnam veterans. Although a wide variety of mammals, birds, tropical fish, and snakes can be infected with *B. pseudomallei,* animals differ widely in their susceptibility to melioidosis. For example, although high mortalities are reported in sheep, water buffalo are remarkably resistant to the disease. Infected animals pass the organism in their feces and are a significant reservoir of infection in the environment.

Medical Aspects

Melioidosis has myriad clinical forms, depending on the site of original infection, the virulence of the infecting organism, and the host's immune status, making diagnosis difficult. Most infections with *B. pseudomallei* in endemic areas are asymptomatic or subclinical (does not rise to the level of noticeable disease symptoms), with the only sign of exposure being an antibody response detectable by serology. Melioidosis may be acute, with rapid progression and death, or it may run a chronic and relapsing course. Illness may develop after a latent period ranging from 2 days to 30 years and usually presents clinically with a fever and signs of sepsis. Upon infection, the bacteria can grow in number and release toxins, usually at a level too low to cause noticeable symptoms. Given enough bacterial growth in the body, however, more serious disease will result.

The most common form of the illness is acute pulmonary infection, which can vary from mild bronchitis to overwhelming necrotizing pneumonia. In the acute localized form, a nodule is found at the site of skin inoculation, and infection may progress rapidly to the bloodstream. Acute bloodstream infection is uncommon in an otherwise normal, healthy host, but it often develops in immunocompromised patients with chronic diseases such as HIV or diabetes, and it can progress rapidly to produce abscesses throughout the body, septic shock, and high fatality rates. Chronic suppurative forms with abscesses in deep organs of the body may also occur.

Melioidosis, like tuberculosis, can be reactivated years after the initial infection or can recur months or years after apparent cure. An estimated 225,000 Vietnam veterans in the United States are serologically positive for melioidosis, but disease reactivation is rare.

To diagnose suspected melioidosis, various laboratory tests are used. For rapid, presumptive diagnosis, gram stain and methylene blue (methods of staining cells and tissue for identification) can be used to visualize the distinctive safety pin staining pattern of the small gram-negative rod in patient specimens, particularly blood, sputum, abscess contents, and skin lesions. Diagnosis is confirmed by *B. pseudomallei* isolation on conventional laboratory culture media, which takes 48 to 72 hours to grow.

Not all strains of *B. pseudomallei* cause disease in humans and animals. *B. pseudomallei* is a frequent laboratory contaminant in endemic areas, and virulent biotypes found in clinical specimens can be differentiated from avirulent environmental biotypes based on the ability to metabolize arabinose (a type of sugar).

Various serological tests have been developed to aid in disease diagnosis, but they are of limited use in endemic areas because of high background positives due to previous exposure, thus have limited specificity. The promise of rapid molecular testing has not yet been fulfilled for diagnosing melioidosis. Currently, there is no immunization for melioidosis prevention, but many antigens found on the organism are possible candidates for a subunit vaccine that uses parts of the organism to develop an immune response. Early intensive intravenous antibiotic therapy with ceftazidine or imipenem is highly effective against acute bloodstream melioidosis, followed by several months of maintenance therapy for prevention of relapses.

—*Amy E. Krafft*

See also: Agroterrorism (Agricultural Biological Warfare)

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MICROENCAPSULATION

Microencapsulation means producing extremely small droplets or tiny solid particles of a material, and covering these particles with a fixed protective membrane. Commercial examples of microencapsulation include dry toner for photocopiers and carbonless copy paper. The microencapsulation of very small particles is a technology that could maximize the effectiveness of chemical or biological warfare agents: Chemical warfare (CW) agents or biological pathogens or toxins could be encapsulated to enhance their survival in a weapon.

Chinese military experts in CW categorize potential applications of microencapsulation for chemical delivery as persistency encapsulation, seepage encapsulation, hydrophobic encapsulation, and time capsules. Persistency encapsulation increases the concentration of CW agents that would otherwise evaporate too quickly for effective use on the battlefield. For seepage encapsulation, the membranes around the particles would slowly release agent for use in contaminating areas or equipment. In the case of hydrophobic encapsulation, a membrane would help to protect the agent from hydrolysis (chemically broken down by water molecules) upon contact with water, enabling CW agents to remain potent for a longer period of time. Time capsules would delay release of the agent until after the membrane deteriorates. It is not known at this time whether any military CW programs have ever taken microencapsulation beyond the stage of basic research.

Microencapsulation also has many applications for biological weapons production. Most biological warfare (BW) agents are composed of microbes or protein-based toxins that are fragile and quickly decay in the open environment. By using special polymers or other biodegradable substances, BW microencapsulation would involve coating liquid or dry BW agents and toxins with materials designed to protect them during aerosolization. Also, when the particles reached the target (most likely lung tissues), the coating could protect the infectious agent from the body's defenses long enough for the agent to cause disease. Microencapsulation can also produce agent particles within a 1–10 micron diameter range, the size that is optimal for infection via aerosol.

For both chemical and biological agents, microencapsulation technology could also help defeat some detection schemes, particularly those that rely on direct contact with the agent in order to send warning signals. Chemical point detection is sometimes dependent on the presence of volatile compounds and their vapors; encapsulating the agent would limit the amount of agent in the immediate area for detection. Properly coated BW agent particles also may confound sampling detection devices that rely on immunodiagnostics, relying upon direct contact with specific biochemical constituents of the organism. But the use of microencapsulation is still a relatively new technique, and it requires an advanced research and development infrastructure. Although most of the publicly known terrorist organizations are unlikely to utilize such technology, state-level CBW programs could certainly employ microencapsulation to produce highly effective weapons of mass destruction.

—Eric A. Croddy

See also: Aerosol; Biological Warfare; Chemical Warfare; Dual-Use

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MUSTARD (SULFUR AND NITROGEN)

Mustard (United States and NATO code HD for distilled mustard) usually refers to sulfur mustard, a classical vesicant (or blister) agent. It was first used by Germany in World War I, later by Italy during Mussolini's war against Ethiopia, and later by Iraq against Iran in the 1980s. Although not as toxic as the nerve agents developed in the 1930s, mustard is still regarded as a significant chemical threat due to its ability to cause mass casualties. As a consequence, especially during the World War I era, mustard was once known as the king of chemical warfare agents. In Germany, mustard was referred to as Lost (from the names of researchers Lommel and Steinkopf, who developed processes for its mass production), and France and Russia named mustard agent after its use at Ypres, Belgium (Yperite).

Other forms of mustard besides sulfur mustard include the nitrogen varieties, coded HN-1, HN-2, and HN-3 in the West. Although the nitrogen mustards differ in some respects from sulfur mustard, the basic mechanism and injuries that result from their exposure are largely the same. Whereas sulfur mustard played relatively important roles in World War I and the Iran-Iraq War (1980–1988), there is little information to suggest that nitrogen mustards have ever been used in battle. Mustard has been shown to be a highly effective casualty-causing agent, especially in military settings.

The effects of mustard agent reverberate in historical and modern contexts. In October 1918, German corporal Adolf Hitler was injured by Allied use

Iraqi 500kg mustard bombs were destroyed by international inspectors following the Gulf War (1991). (UN/Corbis/Sygma)

of mustard agent. Even after its use in World War I, injuries still occur from old munitions left in battlefields from China to Europe. In 1990, for example, a Frenchman suffered serious mustard burns on his hands and arms after he picked up a mustard shell in the old battlegrounds of Verdun.

Sulfur and nitrogen mustards are toxic via a number of routes, including the skin, eyes, and upper respiratory tract. Mustard, an oily liquid, is also more persistent than other true "gases" that were used in the beginning of World War I. (Because the first chemicals used in World War II were in gaseous form, such as chlorine and phosgene, subsequent uses of CW agents were often—and sometimes still are—referred to by the misnomer "gas.") Because of its persistency, opposing forces must wear not only protective masks but also complete protective clothing. Mustard's effects are likewise insidious. Itchy and painful irritation of the skin, leading to sometimes very large blisters (vesicles), occurs after a considerable delay (up to 24 hours).

The mode of mustard's action in the body appears to be cytotoxic—that is, it kills living cells. After coming into contact with living tissue, the mustard molecule forms a highly reactive ion called a free radical. This free radical combines with nucleic acids, cross-linking constituents of DNA by a chemical bond. Mustard then destroys cells from the inside by interfering with DNA synthesis, and it probably affects other important chemicals in the body as well. When these cells die, they release enzymes called proteases, breaking down tissues into liquid exudates (pus). This is the basic process through which blisters are formed. Being oil soluble, mustard readily penetrates the skin, and as it can dissolve through fatty layers, mustard attacks vital organs of the body.

Brief History of Sulfur Mustard

The Belgian Cesar-Mansuete Despretz first synthesized sulfur mustard in 1822, but he did not describe its qualities. The British scientist F. Guthrie repeated Despretz's experiments in 1860 and described mustard as "smelling like mustard, tasting like garlic, and causing blisters after contact with the skin" (quoted in Siddel, Urbanetti, Smith and Hurst, p. 198). Apparently, however, the new compound and its irritating effects did not receive much attention. In 1886, the German chemist Victor Meyer independently synthesized mustard, first by making thiodiglycol and then reacting this nontoxic chemical with chlorine. Surprisingly, this small change produced an extremely toxic chemical, later identified as sulfur mustard. According to Meyer: "The intended work with this chloride was not continued—on account of the extremely poisonous qualities of the compound. It is very striking that this apparently harmless substance which is only slightly volatile, is almost insoluble in water, and has a very slight odor as well as a perfectly neutral reaction, should exert a specific toxic effect. Its chemical constitution would never lead one to expect its aggressive properties" (quoted in Senior, p. 17).

By 1916, after using gaseous chemicals such as chlorine and phosgene, Germany found that both sides in World War I had discovered fairly effective defenses against chemical warfare (CW), primarily through the use of protective masks. After trying—with little success—to use irritating compounds such as diphenylcyanoarsine (DC) in fine dusts to force the enemy to remove their masks, German scientists then looked to mustard. Its attractiveness lay in not only being toxic, but also in its persistence in the field. Decisive animal experiments on mustard were conducted in September and October 1916. The military effectiveness of this agent was already known when the German High Command requested a new CW agent that could be used for the defense of the western front in the summer of 1917.

Sulfur mustard was first tested during the summer of 1916, and it was used at Ypres in July. Because of its persistency and its latency period, soldiers exposed to this chemical often did not know they had been contaminated until injuries manifested themselves later.

Although Germany had confidence that mustard could help turn the tide in World War I, Fritz Haber—chief of the German chemical weapons program—warned that the Western militaries would be able to respond using mustard as well. Haber was right. Corporal Hitler accurately described the effects of mustard: "During the night of October 13–14 [1918] the British opened an attack with gas on the front south of Ypres. They used the yellow gas whose effect was unknown to us, at least from personal experience.... About midnight a number of us were put out of action, some for ever. Toward morning I also began to feel pain. It increased with every quarter of an hour, and about seven o'clock my eyes were scorching as I staggered back and delivered the last dispatch I was destined to carry in this war. A few hours later my eyes were like glowing coals, and all was darkness around me" (Adolf Hitler, *Mein Kampf,* 1924, quoted in Marrs, et al., pp. 161–162).

Although it did not have the lethal effect of phosgene and other gases, mustard agent caused the greatest numbers of wounded throughout World War I. Statistics from the Great War showed that British casualties from CW increased dramatically following the use of mustard agent. With advances in protective gear, however, mortality rates due to mustard agent fell from 6 percent to 2 percent by war's end.

In World War II, CW was limited to the Chinese theater of operations during Japan's invasion of east Asia. Although Winston Churchill had been referred to as a mustard gas fiend, the European militaries and the United States refrained from using chemical weapons during the war. Japan, however, employed a large number and variety of CW agents in China from about 1930–1945. In 1940, Japanese troops used about 600 pounds of mustard against Mao Zedong's communist forces in Shanxi province.

During the Iran-Iraq War (1980–1988), Iraq became desperate to stave off massive attacks of Iranian foot soldiers. Iran had early on adopted a "revolutionary" battle strategy reminiscent of Mao Zedong's People's War—basically throwing bodies at the enemy with little equipment or preparation for battle—resulting in thousands of poorly trained and poorly equipped Iranian troops extremely vulnerable to chemical agents, especially mustard. Like the Germans during World War I, Iraq found value in the use of mustard in roles that could be described as defensive rather than offensive, especially in the later stages of the conflict, when Iraq feared that it could be overrun by Iran's superior numbers. In March 1984, the United Nations confirmed the use of chemical weapons, including mustard, by Iraq.

It is unknown how many Iranian casualties were caused by CW during the war. Figures of 50,000 or more casualties, mostly inflicted by mustard, are certainly possible. At first, Iraq was able to obtain chemical precursors from Western countries, including Europe and the United States. When cut off from these supplies during the war, however, Iraq turned to its domestic petroleum industry for alternative sources. By using oil and breaking it down into ethylene, Iraq found a relatively efficient means to produce mustard agent from indigenous materials. (*See* Iran-Iraq War.)

Nitrogen Mustards

Nitrogen mustards were first developed out of research into nitrogen-carbon compounds during the 1920s and 1930s. In 1931, a chemist by the name of Kyle Ward found that using nitrogen to link chlorinated carbon chains produced a highly potent vesicant. Although the United States Chemical Warfare Service was interested, code-naming the first of these nitrogen mustards as HN-1, it was not considered to be more effective than sulfur mustard. However, the German military found it to be of great interest. Variations on the nitrogen-carbon molecule generated different analogues, some of which were later coded by the U.S military as HN-2 and HN-3. Germany considered the nitrogen mustards to be highly effective for contaminating the ground for area denial and harassing the enemy, and produced some 2,000 tons of HN-1 during World War II. Allied forces destroyed these stockpiles at the end of World War II. Few nations appeared to have produced nitrogen mustard since World War II in large quantity, probably because sulfur mustard production was already in place, and offered many of the same advantages as nitrogen mustard.

Nitrogen mustards are generally more toxic than the sulfur variety and like sulfur mustard are easily manufactured. Both types of mustard cause injury with similar mechanisms. Because of mustard's well-known ability to kill cells, physicians theorized that it could help treat cancer. Experiments found that tumors shrank following treatment with a type of nitrogen mustard called HN-2, also known as mustine (Mustargenor mechloroethamine). Its high toxicity and the introduction of many other chemotherapy options make nitrogen mustard less attractive in medicine.

Mustards Today

Although terrorists might utilize mustard as a weapon of mass destruction, it is not as toxic as other compounds that are available. From a proliferation standpoint, mustard offers a "quick and dirty" option for less developed countries to obtain relatively inexpensive and highly effective chemical weapons.

Because the mustard agents produce blisters on the skin, casualties are at risk for secondary infections and systemic poisoning. By and large, however, injuries to the skin will heal, although there may be significant scarring due to changes in pigmentation. Exposure to mustard agent is particularly dangerous through the respiratory route. In these cases, dead tissue in the upper airways can form "false membranes" that may block the respiratory system, causing death by asphyxia. At present, the primary defenses against mustard are skin protection, taking casualties away from contaminated areas when exposed, and the rapid removal of agent from the skin. Medical treatment options are still limited to supportive therapy.

Although mustard has properties that could lead to the development of cancerous cells, for those who survive single exposures, the risks of cancer are not significantly elevated. Repeated contact with the agent has been shown to be carcinogenic, however, particularly for those employees who worked in mustard manufacturing plants during the world wars. Mustard has a severe injurious effect on the eyes, causing at the very least temporary blindness in low concentrations. However, most victims recover from mustard's effects on the eyes, although some may require corrective lenses or other interventions. In severe cases of exposure, however, permanent blindness is very possible.

—Eric A. Croddy

See also: Iran-Iraq War; Vesicants; World War I

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MYCOTOXINS

Mycotoxins are poisonous chemical compounds that are produced as a by-product in fungal organisms. Mycotoxins are often produced by molds as well. Select toxins produced by fungi, that is, mycotoxins, are considered potential candidates for weaponization as biological toxins. The trichothecene mycotoxins, including T-2 toxin, are putative agents in the weapon known as yellow rain. U.S. allegations that the Soviet Union and its allies used T-2 and other trichothecene mycotoxins in southwest and southeast Asia during the 1970s and 1980s have not been confirmed.

Among all biological toxins that have been developed or proposed as candidate BW agents, the trichothecene mycotoxins (particularly T-2) stand out because of their intensely irritating effect upon the skin. During the 1980s and possibly the 1990s, Iraq researched and developed another mycotoxin for use in warfare: aflatoxin, a highly toxic compound in its own right and one of the most potent carcinogens known (see below).

Mycotoxins were first recognized as being associated with food-borne poisoning caused by moldy grains. In the early eighteenth century, for example, starving soldiers in the army of Peter the Great were forced to eat moldy cereals infected with ergot rust fungus (*Claviceps purpurea*), the same mold that causes a painful condition named St. Andrews Fire. The army was greatly debilitated by eating this moldy grain. In addition to a generalized illness, ergotism can lead to blood vessel constriction and gangrenous tissue. Interestingly, the chemical produced by the fungus, ergotamine, was utilized as a therapeutic agent in old pharmacopeia, especially as a means to control postpartum hemorrhage.

Natural outbreaks of alimentary toxic aleukia (ATA) in the former Soviet Union (especially in Siberia in 1942–1947) affected thousands of people (at least 10 percent of the population) after they ingested grain that was infected with *Fusarium,* a fungus that also produces T-2 toxin. Individuals suffering from ATA developed severe and painful irritation of the digestive tract, skin, bleeding, and suppressed immune systems leading to other disease processes. Similar conditions that gave rise to ATA from trichothecene have occurred in Japan (*akakabi-byo,* or red mold disease), the United States, and Canada. Another illness called cotton lung disease, caused by a fungus that infects cotton (*Dendrochium toxicum*), was described in Russia. More recently, *Fusarium* is reported to be a serious fungal infection and complication occurring in patients who are severely immunocompromised, including individuals undergoing aggressive chemotherapy.

Trichothecene Mycotoxins

Tricothecene (T-2) mycotoxin (i.e., toxin derived from fungi) is unique among the BW agents in that it is immediately active upon contact with the skin. There are a number of fungal genera that produce T-2 or similar toxins, such as *Myrotecium, Trichoderma,* and *Stachybotrys,* with the *Fusarium* species of mold being among the better-known sources. The T-2 toxin stops protein synthesis in cells. Although not nearly as toxic for the nervous system or muscles, T-2 targets those cells that are replaced rapidly, such as the skin, mucous membranes, and bone marrow. Because the *Fusarium* toxin's effects in animals and humans are quite similar to those of ionizing radiation (fever, nausea, vomiting, etc.), these compounds have been termed radiomimetic. The toxicity of T-2 is estimated to be ten to fifty times greater when inhaled as an aerosol than when introduced via injection. T-2 and related substances have been investigated for possible medical uses, including the treatment of some cancerous tumors. A mycotoxin from *Fusarium equiseti* (diacetoxyscirpenol, or DAS) was examined for one such antitumor drug formulation called anguidine. It was found to be far too toxic, however, for routine therapeutic use.

Effects on the human system by trichothecene mycotoxins depend upon the route of exposure. Generally, contact with T-2 aerosols cause severe nausea, vomiting, diarrhea, skin irritation, rash (including blisters), and breathing difficulty. Toxins like T-2 are unique among BW agents in that these toxins have high dermal activity. Severe cutaneous irritation occurs in those who are exposed to dusts generated from hay infected with trichothecene-generating molds. Inflammation of the skin in experimental animals was seen with as little as 25 nanograms of T-2 toxin dissolved in solvent. (A nanogram is one thousandth of a microgram, which is one thousandth of a milligram.) These toxins can also cause acute eye injury, as well as marked effects in the respiratory system.

Because there are no means of detecting the use of trichothecene mycotoxins outside a well-equipped laboratory, in warfare or terrorism, the symptoms of those exposed to the poison would be the primary means of determining that the weapons had been employed. James M. Madsen (2001) notes that clinical diagnosis "of T-2 use as a [weapon of mass destruction] rests on the basis of typical signs and symptoms in the setting of colored smoke, high attack and fatality rates, and dead animals of various species" (Madsen, p. 600). Casualty management is largely limited to decontamination, mostly soap and water, followed by supportive medical care.

T-2 would be a particularly effective casualty agent among unprotected civilians or military personnel, causing enormous pain, general discomfort, and, in large enough concentrations, agonizing death. Trichothecene mycotoxin would also present a contaminating hazard for clothing and equipment. Production of toxin is not considered very difficult, and the toxin could be produced under the guise of "single cell protein" (SCP) manufacture, an activity that under most circumstances would not draw much suspicion. Indeed, it is possible that Iraqi methods of fermenting biological products under the cover of SCP were designed for manufacture of mycotoxins as well as other BW agents.

The exact nature of yellow rain and its relationship to alleged biotoxin warfare by the Soviet Union and client states in southeast Asia remains a mystery. In September 1981, the United States charged that the Soviet Union and clients were using a form of biotoxin against anticommunist guerrillas in Laos, Cambodia, and Afghanistan. The trichothecene mycotoxins were the main component of what the U.S. government alleged was a toxin weapon referred to as "yellow rain." Although there is persuasive evidence to show that mycotoxins were used in southeast Asia in the late 1970s and early 1980s—including pathological samples containing the purported trichothecene mycotoxins—conclusive evidence has yet to prove that Soviet surrogates used trichothecene mycotoxins on the battlefield. Some experts in the U.S. defense establishment still desire more evidence before making a final determination of what occurred. Others state the case for yellow rain rather matter-of-factly and with remarkable detail. For example, in 1997, Robert Wannemacher (a researcher at the U.S. Army Medical Research Institute of Infectious Diseases) and Stanley L. Wiener wrote that trichothecene mycotoxins were involved in some of the following chemical attacks.

"From 1974 to 1981, toxic agents were used by the Soviet Union and its client states in such Cold War sites as Afghanistan, Laos, and Kampuchea (Cambodia). Aerosol-and-droplet clouds were produced by such delivery systems from the Soviet arsenal as aircraft spray tanks, aircraft-launched rockets, bombs (exploding cylinders), canisters, a Soviet hand-held weapon (DH-10), and booby traps (i.e., hidden improvised devices designed to injure or kill military personnel). Aircraft used for delivery included L-19s, An-2s, T-28s, T-41s, MiG-21s (in Laos), and Soviet MI-24 helicopters in Afghanistan and Laos. Attacks in Laos (1975–1981) were directed against Hmong villagers and resistance forces who opposed the Lao People's Liberation Army and the North Vietnamese. In Kampuchea, North Vietnamese troops used 60-millimeter mortar shells; 120-millimeter shells; 107-millimeter rockets; M-79 grenade launchers containing chemicals; and chemical rockets, bombs, and sprays delivered by T-28 aircraft (1979–1981) against Khmer Rouge [Cambodian rebel] troops. The chemical munitions were supplied by the Soviets and delivered by North Vietnamese or Laotian pilots" (Wannemacher and Wiener, p. 654).

Probably because Vietnam was supported by the Soviet Union and elements of the Khmer Rouge were supported by the Chinese government, experts in CW in the Chinese People's Liberation Army also seem to support the charges that yellow rain was used. However, they claim that it was, in fact, a noxious brew of old and new CW agents. Chinese authors Cheng Shuiting and Shi Zhiyuan suggest that "yellow rain claimed about 20,000 victims. Foreign observers believe that 'yellow rain' is a combination of World War I–era mustard gas, combined with a later-developed nerve-type poison that resulted in a third generation CW agent" (Cheng and Shi, p. 9).

Aflatoxin

In 1995, Iraq admitted to having produced mycotoxins, including aflatoxin, for use in biological warfare. Aflatoxin B_1, the most toxic of the aflatoxin analogues, is produced by various molds, most notably *Aspergillus flavus.* Although known for its potential to cause liver cancer in animals, aflatoxin itself has been recognized as a toxic poison. For example, in 1960 in Great Britain, some 100,000 turkeys were poisoned by aflatoxin from moldy grain meal. Although the toxicity of aflatoxin may have been the original reason for Iraq's selecting this BW agent, it is also possible that more mundane and bureaucratic pressures were at work. To demonstrate to their superiors in Baghdad that they were making progress in weapons development, Iraqi BW scientists may have attempted to weaponize aflatoxin because it is relatively easy to manufacture.

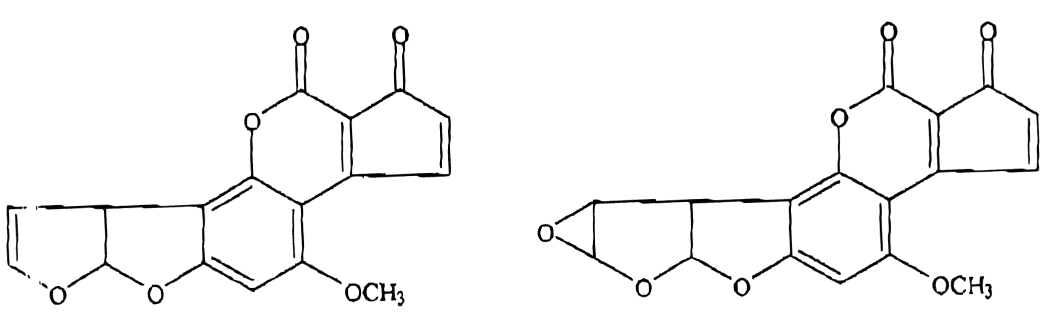
Iraq stated to UN inspectors in 1995 that its research on aflatoxin and other toxins began in 1988. Using the fungus *A. flavus* grown in 5-liter flasks, aflatoxin was produced originally at Al Salman. To step up biological weapons production, aflatoxin production was later moved to Al-Safah, otherwise known as Fudhaliyah, in 1989. According to Iraqi officials, approximately 1,850 liters of aflatoxin solution was produced from April to December 1990. Aflatoxin was then transferred to Al Hakam in January 1991.

From March 1988 to September 1990, Iraq sporadically tested a number of biological weapon delivery munitions, such as LD-250 and R-400 aerial bombs, as well as 122-millimeter artillery rockets. Among the BW agents used to fill these weapons was aflatoxin, probably weaponized in liquid suspension. Iraq also declared that Al-Hussein (modified Scud) missiles were armed with aflatoxin-filled warheads. Although Iraq declared that four of these "special warheads" were filled with aflatoxin, there is some question about whether these actually were filled with another toxin, such as botulinum. Iraqi BW scientists also tested aflatoxin and wheat cover smut (*Tilletia* sp.) spores with silica as a dry preparation.

Beyond the purpose of destroying crops, it is unclear why Baghdad developed these toxins. Iraq might have considered the use of aflatoxin for its long-term carcinogenic properties, especially as a means to attack Kurdish populations opposed to Saddam Hussein's regime, but this seems somewhat far-fetched. No further details of Iraq's work with these or other toxins emerged following Operation Iraqi Freedom (2003).

Aflatoxin can produce long-term effects (e.g., cancer) from repeated exposure, or in large enough quantities, it can cause acute toxicity. In the latter case, aflatoxin interferes with the cytochrome oxidase electron transport system—the essential part of energy utilization in the body—and in this sense it resembles the toxic mechanism of cyanide: The mitochondria (energy-producing organelles) of cells are damaged, resulting in liver damage and related pathologies such as Reyes syndrome, which also includes coma, brain damage, and possibly death. The cancer-causing mechanism of aflatoxin is the result of activation of its molecule by cytochrome P450—an enzyme in the liver that removes toxins—into a reactive epoxide, a chemical constituent containing a highly reactive and damage-causing oxygen group (see Figure M-1). This

Figure M-1: Aflatoxin B1 and Its Reactive Expoxide



Aflatoxin B_1

Reactive epoxide of aflatoxin B_1

can then form harmful chemical bonding with DNA and RNA to impede nucleic acid translation, leading to possible formation of cancer cells in the liver and elsewhere. Due to the carcinogenic properties of aflatoxin, various food grains and other food products, such as peanuts, are closely monitored by industrialized nations for public health purposes.

—Eric A. Croddy

See also: Iraq: Chemical and Biological Weapons Programs; Yellow Rain

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NAPALM

Napalm is technically an incendiary, that is, a weapon designed for destroying targets with high-temperature flame. The inclusion of napalm under the rubric of chemical warfare, while technically incorrect, occurs because it is often developed and handled by chemical warfare services. Napalm is basically a jellified liquid containing a fuel such as kerosene, combined with other components to give it persistence. By thickening flammable liquid in such a manner, napalm (or similar mixtures) becomes more practical to use in aerial munitions and in flamethrowers. The physical properties of napalm enable it to adhere to surfaces, be they materiel or individual soldiers. When delivered from combat aircraft, such as those employed against Japanese forces in World War II, Korea, and the Vietnam War, napalm proved to be devastating against troop concentrations caught in the open.

Napalm was first conceived as a jellied mixture of gasoline and rubber in 1942 when Professor Louis Fieser of Harvard produced a soap combining aluminum naphthenate and aluminum palmitate, the latter consisting of a number of fatty oils. This formula gave the world the name *napalm.* An incendiary bomb produced in 1942, the M-47, utilized gasoline jelly that was ignited by white phosphorus surrounding the TNT-tetryl burster, a high explosive charge. About 80,000,000 pounds of napalm were produced by the United States during World War II for incendiary bombs and flamethrowers. In response to the tenacity of Japanese soldiers, who often fought to the bitter end while ensconced in fortified redoubts, U.S. soldiers increasingly relied on napalm used from the air and in flamethrowers during the World War II island-hopping campaign in the Pacific. In Korea (1950–1953), plastic canisters, each containing 90–100 pounds of napalm, were dropped on North Korean and Chinese positions from the air.

Later, isobutyl methacrylate polymers were employed as thickeners to produce napalm. From 1965–1969, Dow Chemical mixed a polystyrene-gasoline-benzene fuel that was used primarily during the Vietnam conflict. Other applications for napalm included explosive devices attached to 55-gallon drums containing napalm, called fougasse (from the French *fougade,* referring to a type of land mine). These were employed in Vietnam for trip wire perimeter security at military bases.

The use of napalm was often a target of Vietnam War protesters during the 1960s, and it was often mentioned by international critics of U.S policy in Southeast Asia. A now-famous photograph of a young Vietnamese girl (Kim Phuc), who had been severely burned by a U.S. napalm strike, captured for many not only the unpopularity of the Vietnam War, but the perceived immorality of employing Napalm as a weapon.

In 1998, the United States undertook to destroy some 23 million pounds of stockpiled napalm, but this, too, was met with controversy when the napalm was transported across the United States by railcar. As of 2001, most, if not all, of the remaining napalm stores in the United States had been destroyed or recycled into furnace fuel. Although other incendiaries such as fuel-air (thermobaric) munitions have been used and developed for special combat roles, napalm is no longer included in U.S. military planning. Other militaries, such as the Chinese People's Liberation Army, continue to train using napalmlike mixtures for portable flamethrowers and larger devices in armored vehicles.

—*Eric A. Croddy*

See also: Fuel-Air Explosive; Vietnam War

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The United States has destroyed all remaining napalm once used in bombs such as these. (Ross Pictures/Corbis)

NERVE AGENTS

Any chemical compound that poisons the mammalian system by moderating nervous system impulses could technically be considered a nerve agent. In addition to the toxic organophosphates (those chemicals combining phosphorous with a carbon-based structure), other chemical classes such as the carbamates and various cyclic compounds could also potentially be used as nerve agents. Only organophosphorus (OP) compounds, however, have been used as chemical warfare (CW) nerve agents.

During the twentieth century, nerve agents such as tabun (GA), sarin (GB), soman (GD), and VX (or the Russian V-gas) have been weaponized. During the Cold War, both the United States and the Soviet Union maintained thousands of tons of nerve agents in stockpiles. These included sarin, soman, and VX (the Soviet version being a slightly different analogue than the U.S. formula). The U.S. chemical weapons program was halted in 1969, but it was revived temporarily in the mid-1980s by the Reagan administration to counter Warsaw Pact forces in Europe. Although several weapons systems were developed in the 1980s, the United States primarily integrated the binary 155-mm (GB) shell and the VX Bigeye glide bomb into its chemical forces. By 1989, however, the United States and the former Soviet Union had come to an understanding to stand down and disarm their respective chemical inventories. The 1993 Chemical Weapons Convention (CWC) later cemented this agreement in a multilateral disarmament treaty.

Nerve compounds are extremely toxic. In animal studies, the average lethal dose is used as a means for comparing the relative toxicities. The dose required to kill 50 percent of a given population is termed the LD_{50}. It takes more than a teaspoon of the blister agent sulfur mustard, for example, to produce an LD_{50} for skin exposure (percutaneous). The nerve agent VX, by comparison, is about 700 times as toxic as mustard. Nerve agents also have liquid properties that make them amenable to weaponization in artillery shells, rockets, and missile warheads.

Depending upon the operational mission, one nerve agent may be more effective against unprotected troops (e.g., sarin), while another excels at creating highly toxic contaminated areas that can prevent troop movement or deny forces access to materiel or logistics (e.g., VX). As in other types of chemical munitions, high concentrations in a given area can be created by using an aerosol, thereby maximizing the impact of nerve agents on the battlefield. More crude forms of delivery, however, can also be effective. Sarin, for example, forms toxic vapors at room temperature, and it thus could be applied grossly on targets, allowing its volatile fumes to do the rest of the work. A much more persistent nerve agent, VX, does not create appreciable amounts of vapor under normal conditions. However, its dermal (skin) activity and high persistency both make it a prime candidate for rendering areas uninhabitable for troops.

Due to tabun's relative ease of manufacture, it was used by Iraq during the Iran-Iraq War (1980–1988), particularly in the later years of that conflict. Iraqi military units, including its air forces, also mixed a precursor chemical (DF) with cyclohexanol and isopropyl alcohol, forming roughly an equal mixture of sarin and cyclosarin. This procedure was done just before loading the aerial bombs and other ordnance for delivery. Soman was apparently not produced in great quantity by Iraq, probably because Iraq was not able to obtain a key precursor, pinacolyl alcohol, on the open market. Most notoriously, Iraq reportedly used tabun, sarin, and soman against Kurdish populations in the northern part of Iraq, and VX may have been employed from 1987–1988. Some 5,000 civilians perished in the immediate aftermath of the Iraqi chemical attack on Halabja in 1988; nerve agents caused a substantial portion of these fatalities.

Terrorists have generally avoided the use of CW agents, including nerve compounds. However, Japanese cult operatives for Aum Shinrikyo used sarin on various occasions from 1994–1995. The cult also used VX in at least one assassination. There are suspicions that the Islamist organization al-Qaeda, in collaboration with Iraqi CW scientists, has researched the production of VX and other nerve agents for use in terrorist operations. The U.S. Central Intelligence Agency claimed in 1998 that it had obtained a soil sample in Khartoum, Sudan, revealing the existence of a VX precursor, EMPTA (ethyl methylphosphonothioic acid). This led to a U.S. cruise missile strike on August 20, 1998, destroying the Al Shifa pharmaceutical facility in the Sudan. Subsequent analysis has yielded only limited evidence pointing to a direct connection between Al Shifa, the manufacture of VX nerve agent, or Osama bin Laden's al-Qaeda organization. Nevertheless, the trace evidence of EMPTA found near the site does suggest that nerve agent synthesis was being performed at or near the Al Shifa building.

Background: Toxic Organophosphorus (OP) Compounds and Nerve Agents

In the mid-1850s, research chemists Wurtz and Clermont reported on their work with tetraethyl pyrophosphate (TEPP), an OP compound. TEPP (marketed under the German trade name Bladan) was the first widely used insecticide. It was later discovered that TEPP is toxic to mammals, although this toxicity went largely unnoticed until the twentieth century. (Its poisonous character was no doubt revealed when farmers used TEPP in large amounts during the 1930s.) The Russian chemist A. E. Arbuzov also performed groundbreaking work in OP chemistry by the early 1900s.

In the early twentieth century, most insecticides were petroleum based. In an effort to reduce foreign oil imports—as well as to improve its agricultural outputs—Germany undertook wide-ranging efforts to develop new insecticides. The large German chemical firm I.G. Farbenindustrie undertook research into phosphorus-based compounds. (One idea may have been inspired by the German production of synthetic lubricants from phosphorus trichloride.) In 1937, a laboratory team led by Gerhard Schräder synthesized tabun, an extremely toxic OP compound that had more relevance to military chemistry than agriculture. During its initial synthesis in the laboratory, tabun vapors produced characteristic symptoms of nerve agent poisoning among Schräder's laboratory staff. Later, another nerve agent analogue, called sarin, was discovered by the same German chemists. Due to the laws in effect at the time, these formulas were subsequently provided to Nazi Germany for possible military use. Research performed in England in 1941 also characterized the toxic nature of diisopropyl fluorophosphate (DFP). Although not nearly as poisonous as other nerve agents, it nonetheless had the same properties. In addition to possibly using DFP as a CW agent, Allied military chemists saw that it could be mixed with sulfur mustard to lower mustard's freezing point. The advantage of this was the agent could remain liquid even at low temperatures and could be used in winter fighting.

Tabun was manufactured by the German military during World War II at the Dyhernfurth plant in Silesia. Although Germany produced large quantities of tabun (as well as relatively limited amounts of sarin), none of these stocks were used in World War II. (There are suspicions of some use by Germany against Soviet Red Army troops, but these are not confirmed). The compound called soman, the more toxic of the so-called German series of nerve agents, was synthesized by Richard Kuhn in 1944. Soman was also the product of investigations into producing more effective insecticides.

By the early 1950s, the most successful insecticide ever used, DDT, began to wane in its effectiveness against certain pests, including lice. With a market ever widening for substitutes, Ranajit Ghosh, a British chemist at Imperial Chemical Industries Ltd., patented a number of new and promising OP compounds. Using a combination of phosphorus, sulfur, and nitrogen, Ghosh stumbled upon a chemical that was so toxic to mammals that that only the military would have any use for his discovery. Variations on Ghosh's formula would form the most toxic nerve agent to have been weaponized: VX. There currently exist many more analogues of the traditional nerve agents produced in military programs.

Medical Specifics

All known nerve agents possess the same toxicological properties and function in the same way. The OP molecule acts upon human enzymes, the one of most concern being acetylcholinesterase (AChE). The enzyme AChE normally functions as a regulator of the neurotransmitter acetylcholine, thus its name (-ase indicates an enzyme). Under normal circumstances, when a chemical-nerve impulse is generated by the interaction of acetylcholine with a nerve receptor, AChE "grabs" a molecule of acetylcholine and breaks it apart. This subsequently brings an end to the nerve transmission. However, OP nerve agents inhibit the normal activity of AChE. By attaching itself to the enzyme like a key fitting into a lock, the nerve agent stops the action of AChE. The body therefore loses its capacity to break down acetylcholine. This, in turn, brings about a crisis, because nerve receptors are now constantly being stimulated by ever-rising acetylcholine levels.

This ultimately generates life-threatening effects on the respiratory system as well as the central nervous system. Outward symptoms include miosis (constricting of the pupils), and twitching (fasciculation) in the skeletal muscle. More worrisome are copious amounts of secretions in the upper airways, caused by incessant stimulation of glands by high levels of acetylcholine. These fluids can asphyxiate victims of nerve agent exposure. Even if the airways allow for nominal breathing, the repeated nerve-muscular excitation can exhaust the diaphragm, leading to failure of the respiratory system. All of these effects, depending on the dose and route of exposure, can occur within a matter of minutes.

Nerve agent exposures can be dealt with by using (1) drug pretreatment (carbamates), (2) counteraction of increased acetylcholine levels (using atropine), or (3) restoration of impaired enzymes with oximes (e.g., 2-PAM chloride). Drug pretreatment involves ingestion of the drug before possible nerve agent exposure. In the West, pyridostigmine bromide (PB) has traditionally been used to prepare soldiers for combat in chemical warfare environments. Although they are a mild, reversible inhibitor of AChE, carbamates like PB are essentially nerve agents that hold AChE in reserve. Following nerve agent exposure, the subsequently reactivated enzyme then aids in the treatment and recovery of nerve agent casualties. The Chinese People's Liberation Army (PLA), for example, uses a variant of this scheme, prescribing a carbamate compound similar to huperzine, a naturally occurring drug that can cross the blood-brain barrier easier than PB. Although Chinese sources indicate that it is more effective than PB, it is uncertain how this Chinese carbamate might affect soldiers' ability to perform. Thus, the safety-efficacy tradeoff in using drugs for nerve agent exposure might be viewed differently by different national military programs.

Following poisoning with a nerve agent, the compound atropine—a belladonna drug that is related to BZ and that affects the body in a nearly opposite way—helps to restore some normalcy to the victim, drying up the secretions in the upper airways. Militaries usually employ a spring-loaded syringe (autoinjector) to administer atropine in 2-milligram doses, with additional injections called for depending on severity of exposure. In conjunction with atropine, oximes are also delivered by autoinjector. The North Atlantic Treaty Organization and other countries use 2-PAM chloride, and others use a variant for nerve agent casualties. Depending upon the type of nerve agent in question, as well as the time elapsed between exposure and treatment, the oxime is used to free AChE from its nerve agent "trap." Generally speaking, nerve agent casualties treated with atropine and oxime have better chances of survival than those treated with atropine alone. Brain damage and death can result from convulsions caused by exposure to nerve agents; administration of diazepam (Valium) or similar drugs helps to resolve seizures, and these can also be delivered in the field by means of an autoinjector.

Long-term health effects from exposure to toxic OP compounds vary depending upon exposure and the type of nerve agent. The long-tem effect of low-level exposure to these agents is also the subject of considerable controversy. There is not a unanimous opinion among researchers as to the long-term effects of low-level nerve agent poisoning in humans.

Some OP compounds, such as DFP or tri-ortho cresyl phosphate, require higher doses to cause fatalities but have a propensity to inhibit the neuropathy target esterase (NTE) enzyme, which is critical for maintaining proper neuro-muscular functions. This inhibition of NTE can generate a paralytic type of disability in the nervous system and musculature. This effect has been termed OP-induced delayed neuropathy (OPIDN). It is ironic that the toxic nerve agents used in warfare are not likely to produce such symptoms. This is partly because, even in small doses, the CW nerve agents actually cause the most long-lasting and permanent of medical conditions: death. These highly toxic CW nerve agents, however, do not appear to affect NTE levels, and if brain damage can be avoided from nerve agent-induced seizures, full recovery (albeit over weeks or even months) is normally expected, given proper medical care. Thus, survivors of even high doses of nerve agents used in the military context, given proper treatment and time to heal, are not likely to become permanently disabled. Data on voluntary as well as accidental exposures to nerve agents compiled by both British and U.S. chemical weapons programs bear out this finding.

Terrorist attacks involving chemical weapons are, of course, possible. Nerve agents such as DFP that have moderate toxicity and are relatively easy to manufacture may become a weapon of choice. Health care professionals need to be aware of both the short-term and the long-term consequences of OP intoxication.

—*Eric A. Croddy*

See also: Atropine; Aum Shinrikyo; Difluor (DF, Difluoromethylphosphonate); Organophosphates; Sarin; Tabun; V-Agents

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NEWCASTLE DISEASE

Newcastle disease was identified in 1972 in domestic chickens in Newcastle upon Tyne, England. Newcastle disease virus (NDV), also known as fowl pest, is a contagious and fatal viral disease affecting most species of birds. NDV should not be confused with fowl plague. The disease, caused by an avian paramyxovirus—a type of virus similar to those causing rinderpest in ruminants and measles in humans—is so virulent that many birds die from it without showing any clinical signs of infection. Because of the devastating impact that the disease can have on unprotected flocks, NDV can cause significant economic damage.

Although Newcastle infection is transmissible to humans through contact with infected birds, the illness in humans is mild. However, because the virus can result in a death rate of nearly 100 percent in unvaccinated flocks and can affect even vaccinated poultry, Newcastle disease virus could be used as a biological weapon. It is believed that the Soviet Union had investigated the use of NDV as an agricultural weapon.

NDV has recently been investigated as a possible treatment for cancer. NDV appears to reproduce better in human cancer cells than in normal human cells. Lytic strains (those strains that damage the plasma membrane of infected cells) of NDV have been used to kill cancer cells directly in clinical studies. Both nonlytic (those strains that interfere with cell metabolism) and lytic strains of the virus have been used to produce vaccines intended to stimulate the immune system to fight cancer cells. The success of using NDV as a cancer treatment, though, is still unknown.

Newcastle disease virus is highly contagious and spreads primarily through direct contact between healthy birds and the secretions and droppings of infected birds. The virus can also be easily transported on fomites (items such as clothing or shoes that can carry infectious agents) from an infected flock to a healthy one. The virus is rather hardy and can survive for several weeks in a warm, humid environment or indefinitely in frozen material. The virus can be destroyed either through dehydration or through exposure to ultraviolet light. There is no known treatment for NDV, but general biosecurity measures can be used to prevent transmission from infected to healthy flocks.

NDV presents in four clinical syndromes: viscerotropic velogenic, neurotropic velogenic, mesogenic, and lentogenic. Vicerotropic velogenic Newcastle disease is the most severe strain and is often referred to as exotic Newcastle disease (END). Mesogenic is the most common variant found in the United States. Neurotropic velogenic and the lentogenic syndromes vary in their symptomology but are much less deadly forms of Newcastle disease (especially in the case of the latter).

In general, Newcastle disease affects the respiratory, nervous, and digestive systems. The incubation period for the disease ranges between 2 and 15 days, though some birds may never present clinical signs of infection. Symptoms, when they do present, can vary depending upon the viral strain, but they generally show some combination of sneezing, nasal discharge, coughing, shortness of breath, greenish and watery diarrhea, drooping wings, muscular tremors, circling behavior, complete paralysis, partial to complete drop in egg production and/or thin-shelled eggs, swelling of tissue around the neck and eyes, and sudden death. NDV causes only minor illness in humans, characterized by flu-like symptoms.

The END virus variant, which generally affects domesticated exotic caged birds, also affects chickens and other poultry. Although most poultry brooders will vaccinate against NDV, few vaccinate against END. In late 2002, an outbreak that began in California spread to Nevada and Arizona before it was contained. The outbreak was devastating—approximately 3.5 million commercial poultry were euthanized to contain the outbreak.

—*Jennifer Lasecki*

See also: Agroterrorism

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NEWPORT FACILITY, INDIANA

This U.S. Atomic Energy Commission heavy water production facility, used to produce the deuterium isotope in water for nuclear-related activities was later converted to a nerve agent factory. In 1953, the British government gave the United States access to a series of compounds discovered by a British chemical firm (Imperial Chemical Industries) that proved highly toxic to humans. Hardier and more toxic than previously discovered nerve agents, these compounds were further researched by the U.S. Chemical Corps, which decided to initiate large-scale production of one compound designated VX. The facility ultimately chosen to produce the compound had previously been home to an Atomic Energy Commission's heavy water plant in Newport, Indiana.

Completed in 1961, the Newport Chemical Plant operated for 7 years, during which time it was the sole producer of VX nerve agent in the United States (*see* Nerve Agents). As of 2003, the Newport Chemical Plant possessed 4 percent of the original U.S. stockpile in the form of 1,690 steel 1-ton containers containing VX. This agent will be destroyed via a process of neutralization followed by supercritical water oxidation, in which water is heated above 860° degrees Fahrenheit, converting the wastes generated by the neutralization of VX into distilled water and salt.

After original construction of the facility was completed in the 1960s, Newport produced VX in a four-step process. The agent was then used to fill a variety of munitions, including land mines, spray tanks, and rockets. After President Richard Nixon ended U.S. chemical weapons production in 1969 and froze movement of these weapons on U.S. soil, the VX remaining at the facility was placed in storage. At that time, the main plant was decontaminated, but it essentially remained intact. However, under the Chemical Weapons Convention, ratified by the United States in 1997, all former chemical weapons production facilities must either be destroyed or approved for conversion. The Tennessee Valley Authority is responsible for decontaminating and destroying the areas where the first three steps of VX production occurred. The part of the plant where the fourth step, the mixing of the VX precursors, took place is located inside the area where the agent is currently being stored. Destruction of that section of the facility is scheduled to take place once disposal of the agent stored at Newport is complete.

Decisions regarding how to safely destroy Newport's VX stocks took years of study and considerable debate. The U.S. Army finally chose neutralization over incineration as the preferred process. A new destruction facility is under construction and is scheduled to be completed in 2007. After some basic testing, the facility will begin operations. Destruction activities are expected to conclude in 2010.

—Claudine McCarthy

See also: Demilitarization of Chemical and Biological Agents; EA2192; V-Agents

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NITROGEN MUSTARD

See Mustard (Sulfur and Nitrogen)

NORTH KOREA: CHEMICAL AND BIOLOGICAL WEAPONS PROGRAMS

Suspicions of ongoing weapons of mass destruction programs in the Democratic People's Republic of Korea (DPRK or North Korea) have been a focal point of international security concerns since the 1990s. The Korean peninsula remains a volatile region decades after the Korean War, which ended in a cease-fire in 1953. Movement toward unification of North and South Korea has been very slow and fraught with tension. The parties to the conflict never signed a peace agreement and remain technically at war. As a result, one of the DPRK's long-standing aspirations has been to sign a peace treaty with the United States, distinct from any peace treaty involving the Republic of Korea (ROK or South Korea). Not without justification, such a separate peace without southern participation has consistently been rejected by South Korea and the United States, both militaries being partners in defense of the south by potential invasion by the north. This history has exacerbated the security threat posed by weapons of mass destruction in North Korea, for without a coming to terms as to the future of the Korean peninsula—not to mention and end to hostile posturing by the north—the threat of war will continue to persist.

Chemical Weapons

Although concerns about weapons of mass destruction in North Korea have focused on its nuclear weapons program, the country is also believed to possess a longstanding chemical weapons program and stockpiles of chemical weapons. According to various sources, the Korean People's Army developed chemical and biological units and received sarin nerve gas from the Soviet Union in the 1950s. The Soviet Union also reportedly provided small quantities of mustard and nerve agents to the DPRK in 1966. South Korean sources assert that the

U.S. military forces in South Korea train with nuclear, biological, and chemical defensive gear in the event of a North Korean attack. (Reuters/Corbis)

DPRK augmented these acquisitions with domestic production of chemical agents, including mustard and tabun, in the late 1970s. American defense and intelligence agencies have suggested that North Korea moved toward an offensive capability at that time and that it now has the capability to weaponize these agents.

By 2003, estimates of the North Korea stockpile of chemical weapons agents, including nerve, blister, and blood agents, ranged between 2,500 and 5,000 tons. North Korean officials consistently denied these accusations, but they have resisted pressure to join the Chemical Weapons Convention. South Korea alleged in a 1999 white paper that North Korea maintains eight chemical weapons production facilities, four research sites, and six storage facilities.

Biological Weapons

Although it acceded to the Biological and Toxin Weapons Convention in 1987, North Korea allegedly also maintains a rudimentary biological weapons program. At the Fifth Review Conference of the Biological Weapons Convention in 2001, the United States accused North Korea of violating its obligations under the treaty, a charge that North Korea has denied. Sources have reported that the DPRK began production of biological weapons agents, including anthrax bacteria, botulinum toxin, and possibly plague bacteria, in the 1980s. South Korea's Defense Ministry has suggested that North Korea has since then acquired several additional biological weapons, including smallpox, and that it has an ongoing program to weaponize these agents.

—Jacqueline Simon

See also: Korean War; South Korea: Chemical and Biological Weapons Programs

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NOVICHOK

Novichok, or "New Guy," was a top-secret Soviet chemical weapons development program that extended well into the 1990s, even while deliberations continued over the Chemical Weapons Convention (CWC). In the view of some observers, the Novichok program threatened the validity of the CWC as an effective arms control verification regime because Novichok used chemicals not prohibited by the treaty. Novichok agents used precursors similar to those found in fertilizers or pesticides that can be disguised as relatively harmless common chemicals. Consequently, some have argued, even the most intrusive inspection would not be able to identify these agents as chemicals specifically used for weapons production. If the general-purpose criterion of the CWC is to be adhered to, however, any chemical used for toxic warfare is prohibited. Novichok agents, whatever their actual composition, are therefore no less prohibited than any other chemical warfare agents.

Vil Mirzayanov, a Russian émigré, was responsible for bringing the existence of the Novichok program to light. According to Mirzayanov, who was originally responsible for developing detection schemes for Novichok in the Soviet military, the filtration systems in Russia's production and testing sites were not adequate. In the interests of environmental safety, Mirzayanov and another chemist, Lev Fedorov, wrote an article for the weekly *Moscow News* titled "A Poisoned Policy." In this article, they exposed the open-air testing of chemical agents and the inadequate filtration systems that led to contamination of air, water, and soil surrounding the production and testing facilities. The authors accused the Soviet government of poisoning its citizens. Mirzayanov was subsequently jailed for divulging state secrets. He immigrated to the United States in the mid-1990s.

Novichok agents were developed at the Soviet State Scientific Research Institute for Organic Chemistry and Technology (GosNIIOKhT) as part of a third-generation chemical weapons program. Research efforts included methods of delivering these chemicals in unitary and binary form. (Binary agents are advantageous because they allow the chemicals to remain separated and nontoxic until the weapon is deployed, at which time the chemicals mix and become lethal). According to Mirzayanov, the Chemical Research Institute, located in Nukus, Uzbekistan, was a major research and testing site for Novichok. There was also a relatively small test area near Krasnoarmejsk, a Moscow suburb. The Nukus facility was built in 1986 to produce small batches of novichok agents for testing in binary weapons. According to Mirzayanov, testing demonstrated that novichok agents would be effective military weapons in both unitary and binary forms. Novichok agents can be dispersed as a liquid, aerosol, or gas, and they can be used in a variety of delivery systems (bombs, artillery shells, spray rigs, and missiles).

The actual chemical and physical characteristics of novichok agents are still unknown. According to Mirzayanov, novichok 5 is estimated to be five to eight times more toxic than VX, and novichok 7 is estimated to be ten times more toxic than soman. The effects of novichok agents are rapid, and the progression of symptoms is similar to that of other nerve agents (pinpoint pupils, runny nose, tightness of chest, nausea, vomiting, involuntary twitching of muscles, loss of consciousness, and, eventually, death). Despite the fact that they produce similar symptoms, the novichok agents are different in their chemical structure from the traditional G-series or VX nerve agents.

Media reports have indicated that novichok agents cannot be detected by Western technology, particularly those chemical warfare agent detection systems used by NATO militaries. Reportedly, should a chemical alarm be set off by the presence of a novichok agent, the substance would not be identifiable and would appear to be a false alarm. Apparently, the novichok class of compounds falls outside the identification range used in many chemical detection systems.

There is still much to learn about the Novichok program. The Russian government continues to withhold information regarding this secret weapon. Meanwhile, the Uzbek government is working closely with the United States to dismantle and decontaminate chemical weapons testing facilities within their borders. Soil samples and other tests may be able to provide more information on the physical makeup of novichok agents that were tested at the Nukus facility.

—*Stephanie Fitzpatrick*

See also: Nerve Agents; Russia: Chemical and Biological Weapons Programs

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OKLAHOMA CITY BOMBING

On 19 April 1995, Timothy McVeigh—a domestic terrorist with antigovernment beliefs—drove a rented cargo truck to Oklahoma City and parked in front of the Alfred P. Murrah Federal Building. While driving to the intended target—the U.S. federal government and its enforcement agencies located there—he had already lit the fuse that protruded from the cargo hold into the cab of the truck. He parked the vehicle at a drop-off point near the building and walked away. Inside the truck were approximately 5,400 pounds of ammonium nitrate, 1,200 pounds of nitromethane, and a 350-pound high explosive charge. Diesel had also been added to some of the ammonium nitrate in the back of the cargo container. Essentially, the truck was an ammonium fuel oil (ANFO) explosive weighing about 7,000 pounds. Although McVeigh was wearing ear plugs and was at least two hundred yards away from the blast, the resulting explosion nearly deafened him. The bomb destroyed the building, killing 168 people, 19 of them young children.

The bombing at Oklahoma City was the second most devastating terrorist attack on American soil, eclipsed only by the attacks to come six years later on 9/11. But unlike the assault on the World Trade Center in New York, the origins of the Oklahoma City bombing were entirely domestic. Furthermore, it established a precedent for the U.S. Federal Bureau of Investigation to define a weapon of mass destruction along the following lines:

> Mass casualties and extensive property damage are the trademarks of weapons of mass destruction, making their detection, prevention, and destruction an FBI priority. A weapon of mass destruction (WMD), though typically associated with nuclear/radiological, chemical, or biological agents, may also take the form of explosives, such as in the bombing of the Alfred P. Murrah Federal Building in Oklahoma City, Oklahoma in 1995. A weapon crosses the WMD threshold when the consequences of its release overwhelm local responders. (FBI, 1999)

In 1997 McVeigh was convicted of murder and employing a weapon of mass destruction (WMD) "to kill and injure innocent persons and to damage the property of the United States." (Quoted in Michel and Herbeck, p. 347). Finally, after waiving his right to appeal the death sentence verdict, McVeigh was executed by lethal injection on 11 June 2001. Another co-conspirator, Terry Nichols, was convicted for the Oklahoma City bombing on 26 May 2004, but on 11 June 2004 he was spared execution by a deadlocked jury during his sentencing. He will spend the rest of his life in prison.

The timing of the Oklahoma City bombing was to protest—as well as to dramatically commemorate—the U.S. government's actions at Waco, Texas, in 1993. On 28 February 1993, federal agents from the Bureau of Alcohol, Tobacco, and Firearms (ATF), while serving a firearms violation warrant, raided a compound at Waco that housed members of a cult (Branch Davidians) led by David Koresh. It led to a shootout and siege that continued for over a month. McVeigh had even driven to Waco in March 1993 in order to witness the spectacle but was denied entry to the area by local law enforcement. On 19 April 1993, a fire consumed the Branch Davidian compound, killing more than 80 of the people inside, including 21 children. Later investigations showed that the use of CS riot control agent by Federal agents—as well as actions taken by David Koresh and his followers—contributed to the final death toll.

By the time he heard of the tragic aftermath at Waco, McVeigh, a former U.S. Army soldier and a

Gulf War veteran, had already developed antigovernment sentiments. Loosely associated with the militia movement in the Western United States, McVeigh intended to retaliate against these federal agencies by destroying the federal building in Oklahoma City. On 18 April, with assistance from Nichols, McVeigh assembled the truck bomb at Geary Lake State Park in Kansas. A day later, McVeigh drove the truck to Oklahoma City, timing the attack to ensure the building was full of federal workers, including federal agents of the ATF—the same agency that McVeigh blamed for the conflagration at Waco, Texas. An hour outside of the city McVeigh was pulled over by Oklahoma highway patrol for driving without a license plate, leading to his arrest.

—*Eric A. Croddy*

See also: Ammonium Nitrate Fuel Oil; Terrorism with CBRN Weapons

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ORGANOPHOSPHATES

Many important chemical substances can be categorized as organophosphates. These chemicals possess a structure that is composed of carbon-hydrogen bonds linked in some fashion (often via an oxygen atom) to a phosphorus atom. Since their discovery in the nineteenth century, organophosphates have found many uses.

Organophosphate (OP) synthesis begins with phosphorus, often in the form of phosphorus trichloride, phosphorus oxychloride, or phosphorus pentasulfide. Although the process chemistry to produce OP compounds is not exceptionally difficult, the challenge for some countries or groups might be finding a source of phosphorous itself: a more difficult undertaking, as there are limited producers. Although many of these OP compounds have useful roles in agriculture and modern industry, the development of OP compounds for use as insecticides in the 1930s led to the development of the military nerve agents, which are also OP compounds. These compounds top the list of chemical threats that could be used in modern weapons of mass destruction (WMD), including for purposes of terrorism.

Background

The chemist Wurtz discovered a chemical compound known as tetraethyl pyrophosphate in the mid-1800s but did not report on its toxicity. It is now known as a relatively potent nerve agent. In the nineteenth century, the German chemist Carl Arnold August Michealis worked with phosphorus-related compounds as a focus of his research. In the 1920s, the Russian scientist A. E. Arbusov published his own work on phosphorus. In 1932, German research chemists Lange and von Krueger reported on toxic properties of some OP agents. They noted that upon exposure, a fluorinated OP chemical they synthesized caused breathing difficulties, and "glare phenomena with painful hypersensitivity of the eye to light" (Franke, p. 201). During the course of research into producing new insecticides without using scarce petroleum, German chemists in 1937 found some OP compounds that were highly lethal to mammals and therefore had no useful role in agriculture. But these chemicals had obvious military applications. Gerhard Schräder's team would eventually discover the more potent chemical compounds tabun and sarin.

At the start of World War II, research in the United Kingdom independently discovered the toxic properties of a nerve agent, diisopropyl fluorophosphate (DFP). But knowledge of the much more toxic analogues, including tabun and sarin, would have to wait until war's end and the fall of Berlin. In 1945, British and U.S. intelligence organizations were quite surprised at the extent of Germany's research and development of OP compounds for military use.

Medical Aspects

The nerve agents inhibit the work of the body's enzymes—most critically that of acetylcholinesterase (AChE), but they will also interfere with other enzymes. The toxic nature of these OP compounds is due to their affinity for AChE. This enzyme controls the amount of acetylcholine in the nervous system by catalytically breaking it down into its constituent parts. Too much acetylcholine causes hyperstimulation of the nervous system, including important glands and the musculature.

Nerve agents work on the body and its enzymes by acting like neurotransmitters. Toxic OP agents like sarin, tabun, and VX possess a phosphorus atom that bonds with a chemical group on the enzyme. The other part of the OP molecule mimics the properties of acetylcholine, a neurotransmitter in the nervous system. The analogy of a lock and key is apt: normally, acetylcholine is the perfect key for the AChE lock, fitting nicely and allowing the continuation of normal operation. The OP chemical, however, is a pseudokey that finds its way into the enzyme (lock). Like a poorly copied key that gets stuck in the mechanism, the OP compound can render the lock useless—sometimes the key even breaks off inside, and it now becomes a hopeless task to repair it. (This process of binding with the enzyme, sometimes reversible but at a slow rate, is often referred to as phosphorylation.) With no enzyme to control the amount of acetylcholine, excessive stimulation leads to crisis and death of the body. Some chemicals can be used to help repair AChE, such as oximes. In the case of soman poisoning, however, the bond is basically irreversible within minutes of exposure, and in these cases oxime therapy is not as effective.

Other Uses for Organophosphates

Besides nerve agents, another role for OP compounds is in removing or chelating heavy metals, such as uranium, for extraction and purification. Tributyl phosphate (TBP) is an essential chemical used in the processing of plutonium (plutonium uranium recovery by extraction or PUREX) and uranium for nuclear weapons development. TBP is the workhorse for extracting plutonium from irradiated fuel rods. Another OP compound used in uranium extraction is trioctylphosphine oxide (TOPO), often used with bis(2-ethylhexyl) phosphate (DEPA), another organophosphate. The DEPA-TOPO process removes uranium, which is then extracted from a solvent (such as kerosene).

Although infamous for their role in weapons chemistry, OP compounds also contribute to very useful and lucrative chemical markets in a variety of other applications, including pesticides, herbicides, antivirals, lubricants, flame retardants, and plasticizers (see below).

Some of the first OP compounds to be successfully marketed included the triphenyl (generally referred to as triaryl) phosphates and the tri-cresyl phosphates. These chemicals were useful as plasticizers, making substances such as celluloid and vinyl more flexible, while also adding a flame retardant effect. Other uses included treatment of

TOCP POISONING: OR THE HAZARDS OF UNREGULATED BOOZE

One OP compound that targets the body's enzyme function and causes devastating effects on the nervous system is tri-ortho cresyl phosphate (TOCP). During the 1930s, some 50,000 people in the United States unwittingly ingested TOCP while drinking "ginger jake" tincture. Due to the prohibition of alcohol enacted at that time in the United States, those who desired alcoholic beverages had to resort to improvised sources. One such source was a ginger extract that contained 70–80 percent alcohol. Originally conceived as a tonic and a purgative, "jake" was sold for 50 cents per bottle, and although still somewhat expensive for the day, it was a cheaper option than bootleg liquor.

One businessperson who produced and sold this concoction, Harry Gross, president of the Hub Products Corporation, decided to cut manufacturing costs by adulterating jake with cheaper solvents. It was suggested that a varnish component marketed as LINDOL could be added. The main component of this varnish was TOCP. More than 640,000 bottles of jake were produced with this adulturant in Boston, Massachusetts, and were eventually distributed by American pharmaceutical companies.

At that time, TOCP was deemed "presumably nontoxic," but soon after the shipments of jake were sold on the street there appeared cases of "Jake walk" or "Jake leg," described as a characteristic foot- and wrist-drop symptomatic of a serious motor paralysis. It is now known that TOCP and/or its toxic metabolite targets the enzyme neurotoxic esterase (NTE) in the nervous system, resulting in a severe and debilitating nerve dystrophy. When taken in only small quantities, symptoms were relatively minor and usually resolved themselves. Others who consumed more of the product suffered chronic partial or even complete paralysis. Even as late as 1978, survivors continued to display typical polyneuropathies of TOCP poisoning.

The individual responsible for this "mass poisoning," Harry Gross, received a two-year jail sentence (suspended) and a $1,000 fine a few years later, but none of his victims received anything in the way of compensation.

leaded gasoline to cut down on premature firing, although this is no longer needed with the advent of unleaded fuels. Because they are not as flammable as oil mixtures, OP compounds are also being used as hydraulic fluids and lubricants in gas turbines and other platforms.

By far, the largest group of OP compounds used commercially is the pesticides, including insecticides and herbicides. Although DDT was effective and relatively safe to use, insects quickly developed a resistance to this and other chlorine-based organic chemicals. As the German chemists noted early in the 1930s, the OP nerve agents were highly effective against insect pests. The challenge was to find those OPs that did not kill animals (and humans) as well. Since then, a number of highly successful OP insecticides have been marketed and are still used today, including malathion and chlorpyrifos. It has been found that although flies and mosquitoes develop a resistance very quickly against chlorinated organic pesticides—say, within a dozen generations or so—it takes much longer for the same insects to develop resistance to OP compounds. A further advantage to OP pesticide chemicals is that they quickly hydrolyze (are broken down by water) in the environment. Hazards of using OP insecticides most often occur when farmers use these chemicals without strict adherence to labeled instructions, as these insecticides are sold in bulk form at high purity for agribusiness.

The development of glyphosate (sold as a product called Roundup) herbicide is another example of a very successful OP chemical whose markets for use continue to expand. This is especially true with the recent introduction of genetically modified crops that tolerate the chemical ("Roundup Ready"). The agrichemical giant Monsanto, for example, has developed Roundup Ready soybeans for use in tandem with glyphosate, for more efficient use of the herbicide and for increased yields.

OP compounds also account for nearly 25 percent of the market for flame-retardant chemicals. These substances provide a chemical buffer between the flame source and the fabric, allowing fibers to char but not burn. In pharmaceutical applications, drugs such as Foscarnet (antiviral) and other promising compounds are being used in microbial chemotherapeutics. These are also based on OP chemistry.

—Eric A. Croddy

See also: Nerve Agents

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OSAMA BIN LADEN

Osama bin Laden is the leader of the global Islamic terrorist organization al-Qaeda (*see* al-Qaeda), which was responsible for perpetrating the September 11, 2001 attacks against the United States. Bin Laden has openly stated that he and his followers wish to acquire weapons of mass destruction (WMD) and to use them against American and other Western interests.

Bin Laden was born July 30, 1957 in Riyadh, Saudi Arabia. His mother, Hamida, was originally from Damascus, Syria. His father, Muhammad bin Awdah bin Laden, was originally from Yemen and had four wives and many concubines. Bin Laden was the seventeenth of fifty-two siblings. His father is founder and owner of the Saudi bin Laden Group, a respected construction firm in Saudi Arabia and the Middle East.

Bin Laden was raised in Medina, Saudi Arabia and attended primary and secondary schools in Jeddah, Saudi Arabia. Bin Laden attended King Abdulaziz University for three years, where he studied economics and management but did not graduate. At the university, he also studied Islam with Muhammad Qutb and Abdullah Azzam, both important Islamic fundamentalist thinkers. Bin Laden went to Afghanistan in 1979 following the Soviet invasion of that country, serving as part of the mujahideen (holy warriors) resistance. His motivation—as it was for the rest of the mujahideen—was the desire to expel atheistic Russians from a Muslim state. In Afghanistan, he became even closer to Abdullah Azzam. In 1984, the two formed the Afghan Service Bureau (MAK) to recruit and train mujahideen fighters. Although bin Laden played

Osama bin Laden may have begun serious efforts to acquire WMD while in the Sudan. (Reuters/Corbis)

mainly a support role during the Afghan conflict with the Soviet Union, he did take part in a handful of battles. In 1988, bin Laden reportedly formed the "base" organization formed by mujahideen and other radical Islamists, called al-Qaeda. By 1989, however, a growing rift between Azzam and bin Laden over the future direction of MAK led bin Laden to sanction the assassination of his former mentor and partner. In November 1989 a bomb killed Abdullah Azzam and two of his sons in Peshawar, Pakistan; the perpetrator is still unknown, although bin Laden is suspect.

After the Soviet withdrawal from Afghanistan in 1989, bin Laden returned to Saudi Arabia, where he helped Saudi intelligence found a jihad group in southern Yemen to oppose the communist government in that country. After the Iraqi invasion of Kuwait in August 1990, bin Laden proposed that he and the Saudi government form an Arab, anti-Saddam Hussein group made up of 5,000 Afghanistan veterans to guard Saudi Arabia against a possible Iraqi invasion. The Saudis rejected his proposal and invited the United States military to Saudi soil instead, a move that angered bin Laden. When the Saudi government broke its promise to him to bring about an immediate U.S. withdrawal after the war, bin Laden became very outspoken in his views against the Saudi government.

Fearing assassination by the Saudi government, bin Laden left Saudi Arabia in April 1991, moving his base of operations to Sudan. In 1994, Saudi Arabia revoked bin Laden's citizenship. In retaliation, he formed the Advice and Reformation Committee, which proceeded to agitate within Saudi Arabia against the Saudi royal family. Later in 1994, the Saudi government attempted to assassinate bin Laden. In response, bin Laden ordered the bombing of targets within Saudi Arabia, including the National Guard Building in 1995 and the Khobar Towers in 1996, the latter killing nineteen and wounding over 500 American military personnel. In response to growing international pressure, Sudan expelled bin Laden in May 1996.

Bin Laden then moved his headquarters to Afghanistan, where he developed a relationship of mutual cooperation with the ruling Islamic fundamentalist Taliban regime. During 1997 and 1998, bin Laden worked to form an international Islamic fundamentalist coalition. In February 1998, he announced the formation of a larger umbrella organization, with Al-Qaida ("the base") leading the World Islamic Front for the Jihad against the Jews and the Crusaders (*Al-Jabhah al-Islamiyyah al-`Alamiyyah li-Qital al-Yahud wal-Salibiyyin*), saying that it was the duty of all Muslims to kill Americans.

As a result of bin Laden's 1998 U.S. Embassy bombings in Kenya and Tanzania, the U.S. government tried to kill bin Laden and weaken his network by carrying out cruise missile strikes against training camps in Afghanistan and against the alleged chemical weapons production facility at the Al Shifa pharmaceutical factory in Khartoum, Sudan (*see* Al Shifa). Bin Laden was not killed by the U.S. strikes but was instead vaulted to further preeminence as an Islamic fundamentalist figure in the Muslim world, partly as a result of the U.S. military response.

According to some reports, bin Laden has used his inheritance from his father's business, estimated at between $25 million and $300 million, to fund al-Qaeda's operations. However, other recent stories in open sources have concluded that bin Laden has long since spent his fortune and now relies on foreign assistance and donations. Due to his previous dealings with Abdullah Azzam, bin Laden has been described as duplicitous. Although not known as an original thinker himself, bin Laden is a competent manager and businessman who surrounds himself with talented advisors. He has also been described as an opportunist, given his willingness to ally himself with those who can contribute to his success, even if these allies do not completely support his ideological vision.

Bin Laden first expressed an interest in acquiring and using weapons of mass destruction while in Sudan. During that time, he began his network's WMD research with the help of the National Islamic Front (the ruling regime in Sudan) and the Sudanese military. Bin Laden has been very open about his desire to acquire and use WMDs. He has stated publicly his belief that acquiring WMDs is a Muslim duty and even that the failure to acquire WMDs is a sin.

—Sean Lawson

See also: Al-Qaeda; Al Shifa; World Trade Center Attack

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OXIMES

In the treatment of nerve agent casualties, oximes are a category of therapeutic compounds used to help restore acetylcholinesterase (AChE) enzyme function (*see* Nerve Agents, Atropine). In the battlefield, oximes can be administered with the use of a spring-loaded syringe for self administration (autoinjector), along with atropine and anticonvulsant (diazepam) therapy. Civilians also may require oxime therapy in the occasional case of poisoning by organophosphate insecticides (*see* Organophosphates).

The general approach to nerve agent antidote regimens includes an injection of atropine to counter the immediate effects of the nerve agent. Next, the administration of oximes helps the body to restore the balance of its nervous and muscular function by "repairing" enzymes that are blocked by the nerve agent. By speeding up the process of hydrolysis (cleaving off the nerve agent with water molecules), oximes provide more leverage to separate AChE from the nerve agent.

Atropine can counter the effect of dangerously high levels of acetylcholine, which otherwise would overstimulate glands and cause respiratory crisis. Oximes help to restore AChE enzyme to normal function, but it does not appear to treat chemical imbalances in general. The chances for survival are much better when antidotes combining both atropine and oximes are used. Along with atropine, oximes are fielded in autoinjectors that can be carried by each soldier and by emergency medical personnel. One treatment called TAB has been a long-standing mixture for bolus administration, consisting of trimedoxime (TMB4), atropine, and benactyzine (the latter serves the role of a carbamate to help protect AChE).

Some oximes work better than others, depending on the type of nerve agent that may be encountered. Soman, for example, is a nerve agent that is notoriously difficult to reverse, and standard pralidoxime chloride (2-PAM-Cl) therapy has shown little or no reversing effect. In the case of tabun, the oxime TMB4 (the acronym for N,N'-trimethylene bis-[pyridine-4-aldoxime bromide]) is more effective against tabun than is 2-PAM-Cl, for example. Other oximes are being studied that can make up for deficiencies, depending upon which nerve agent is encountered. Following nerve agent exposure and immediate treatment, follow-up care may be necessary to prevent long-term neurological damage, and anticonvulsants (such as diazepam) are often prescribed in such cases.

There are several types of oximes that have been developed by militaries around the world. Which oxime is used depends on each country's view of risk versus benefit among the different compounds that are available. In the U.S. military, 2-PAM-Cl is the standard drug used to treat chemical weapons casualties. It is also the treatment of choice for organophosphate insecticide poisoning. A pralidoxime called P2S is employed by the British armed services, and obidoxime and TMB4 are used in other European nations. As seen in the Table O-1, hagedorn (HI-6 and HS-6) oximes appear to be at least marginally effective in experimental studies of soman poisoning. However, this may be due to factors unrelated to the inhibited enzyme.

Table O-1: Comparison of Oximes and Their Effectiveness in Countering Nerve Agent Poisoning

Oxime	*Sarin*	*Tabun*	*Soman*	*VX*
2-PAM-Cl	+	+	0	+
Obidoxime	+ + +	+ +	0	+ + +
HI-6	+ + + +	0	+ +	+ + + +
HS-6	+ + +	0	+	+ + +

(Plus signs indicate relative effectiveness, while 0 means no appreciable effect)

Oximes and "Aging"

Oximes are only effective if administered promptly after nerve agent exposure. In the case of soman poisoning, the effective oxime treatment window may be a matter of minutes. As a consequence, if U.S. troops are thought to be facing a threat from soman nerve agent, pretreatment with a carbamate (e.g., pyridostigmine bromide) has been recommended (*see* Carbamates).

The chemical process that leads to enzyme aging depends largely upon the type of nerve agent encountered on the battlefield. In the case of soman, cyclosarin, and some others, the aging depends upon a large functional group (the esteric portion made of an alcohol such as isopropyl in the case of sarin) attached to the molecule of the nerve agent. Once the first leaving group, the portion that first dissociates from the phosphonic ester (such as fluorine in the case of sarin or soman) is removed through hydrolysis (cleaving with water), the molecule with the active phosphorus entity will then phosphorylate AChE—that is, the nerve agent molecule bonds with the enzyme, effectively inhibiting its function. At this point, there is a chance that hydrolysis—either by itself or with an assist from an oxime (such as 2-PAM-Cl)—could take place. However, at some point (quickly, in the case of soman), the large structural unit also leaves the phosphate structure of the nerve agent molecule. Now, the phosphorous atom is highly resilient to hydrolysis, basically repelling water molecules away. This is now a so-called "aged" enzyme and cannot be practically restored to normal function.

Studies suggest that therapy using atropine (or similar drugs) together with oximes offers better therapeutic success than atropine alone. Without oximes, the natural course of events may allow for hydrolysis and dephosphorylation of nerve agent to take place, albeit at a very slow rate, thereby reversing AChE inhibition. If this process fails, however, oximes come to the rescue. In certain cases, however, as in the aforementioned problem with soman poisoning, the enzyme may "age." If this occurs, there is no hope of hydrolysis to restore the enzyme—with or without oxime therapy—lessening the chances of survival or vitiating fast and full recovery.

—Eric A. Croddy

See also: Atropine; Nerve Agents; Organophosphates; Pyridostigmine Bromide

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P

PARASITES—FUNGAL

Although many disease-causing microbes are obligate parasites—requiring a host to survive and duplicate, such as viruses and most rickettsial bacteria—the term *parasites* generally refers to eukaryotic (unicellular parasites such as fungi, protozoa, nematodes) rather than prokaryotic (not having a distinct nucleus, such as bacteria) organisms. By virtue of their capacity to infect via aerosol, some fungal pathogens, such as *Coccidioides immitis* (the causative agent of coccidioidomycosis or valley fever) and *Histoplasma capsulatum* (histoplasmosis), have been studied for potential use in biological weapons.

Fungal organisms that could have potential as biological warfare agents include:

- *Blastomyces dermitidis* (also known as *Ajellomyces dermatitidis*)
- *Cladophialophora bantiana* (formerly known as *Xylohypha bantiana, Cladosporium bantianum*)
- *Coccidioides immitis*
- *Coccidioides posadasii*
- *Histoplasma capsulatum* (incl. var. *duboisii*)
- *Histoplasma capsulatum* var. *farcinimosum*
- *Paracoccidioides brasiliensis*
- *Penicillium marneffei*

During World War II, *C. immitis* was studied at the Stanford University School of Medicine for the U.S. War Research Service. Because African Americans have traditionally shown susceptibility to coccidioidomycosis, this disease was of concern to the U.S. military during the war. After the war, some experiments were conducted that violated legal guidelines for such research: In 1951, U.S. Army scientists carried out studies of this pathogen using a relatively innocuous fungus, *Aspergillus fumigatus,* exposing a disproportionate number of African Americans as test subjects without their prior consent. Between 1943 and the end of the U.S. offensive biological weapons program in 1969, ten researchers at Fort Detrick, Maryland, became infected (presumably by accident) by fungal organisms during research into their potential as biological warfare (BW) agents. Nine of these infections were caused by *C. immitis,* the other being caused by blastomycosis (*Blastomyces dermitidis*).

Fungi offer potential as antihuman agents primarily because of their natural propensity to disperse as small particles in aerosols. Fungal organisms such as *C. immitis* can be carried long distances in the air, causing numerous infections every year. Diseases such as valley fever and histoplasmosis are prevalent from the southwestern to the central and eastern parts of the United States and are a serious public health issue. When compared to a number of other pathogens that could be used in BW, however, it is not clear that their potential to cause widespread disease is sufficient to warrant much concern.

Another possibility exists that molds such as *Fusarium* sp. could be utilized to produce mycotoxins (*see* Mycotoxins) for use in warfare.

Fungi and other parasites also may be used as an anticrop weapon. The real threat these agents pose to modern agricultural industries is not clear, but the following pathogens are included in some lists for purposes of biological arms control:

- *Bipolaris oryzae* (also called *Helminthosporium oryzae, Cochliobolus miyaeanus*), brown spot of rice
- *Colletotrichum coffeanum* var. *virulans* (also known as *Colletrichum kahawae*)
- *Deuterophoma tracheiphila* (also known as *Phoma tracheiphila*), mal secco disease

- *Dothistroma pini* (also known as *Scirrhia pini*), needle blight on/of pine
- *Microcyclus ulei* (also known as *Dothidella ulei*), South American leaf blight
- *Moniliophthora rorei* (also known as *Monilia rorei*), cocoa moniliasis
- *Phytophthora infestans,* late blight of potato
- *Puccinia erianthi* (also known as *Puccinia melanocephala*), orange rust of sugar cane
- *Puccinia graminis* f. sp. *tritici,* rust fungus
- *Puccinia striiformis,* wheat yellow rust (*Puccinia glumarum*)
- *Pyricularia grisea* (formerly known as *Pyricularia oryzae,* also *Magnaporthe grisea*), rice blast fungus
- *Sclerotinia sclerotiorum,* Sclerotinia rot
- *Ustilago maydis,* corn smut
- *Tilletia* sp., wheat cover smut

As for protozoans, nematodes, or even insects that can cause significant disease in humans, few if any known military programs have seriously investigated or developed such organisms as biological warfare agents. However, some negotiators of a verification protocol to the 1972 Biological and Toxin Weapons Convention have included parasites in suggested pathogen lists for arms control. Past experience also suggests that bioterrorists, or perhaps criminal saboteurs, might consider using these pathogens as a weapon. Although it is difficult to foresee a significant threat from these parasitic organisms, the following agents may pose a threat if used for sabotage or purposeful contamination:

- *Echinococcus granulosus*
- *Echinococcus multilocularis*
- *Echinococcus vogeli*
- *Leishmania brasiliensis*
- *Leishmania donovani*
- *Naegleria fowleri* (naegleriasis, or amoebic meningoencephalitis)
- *Plasmodium falciparum,* malaria
- *Taenia solium,* pork tapeworm, cysticercosis
- *Trypanosoma brucei rhodesiense*
- *Trypanosoma cruzi*

Two additional parasites (more precisely referred to as protozoa), *Giardia lamblia* and *Cryptosporidium parvum,* also pose a public health hazard today. For example, a scientist who belonged to the Rajneeshee cult in Oregon (1984) reportedly considered using *Giardia lamblia* as a weapon. This parasitic organism causes giardia, a serious but usually self-limiting (resolves on its own) infection with symptoms mostly consisting of diarrhea. The idea apparently came to the attention of the cult scientist because beavers, common to the Pacific Northwest United States, are a well-known carrier of the parasite. One plan may have included finding an infected animal, putting tissues such as certain organs in a blender, and collecting the protozoa.

Deliberate spreading of giardia to humans could be accomplished by adulterating food or water. The practicality, however, of isolating, growing, and preparing a concentrate of this protozoan is hard to assess. In the 1984 case, the Rajneeshees instead chose the *Salmonella typhimurium* bacterium and used it to contaminate salad bars throughout The Dalles in north-central Oregon, hoping to change the outcome of local elections. They failed to influence the election, but (despite the fact that the bacterium was a nonlethal pathogen) 751 people became ill, making this thus far the largest bioterrorist attack on record.

In the United States and elsewhere, *Cryptosporidium parvum,* the causative agent in cryptosporidiosis, also causes severe diarrheal symptoms in humans. As in giardia infections, cryptosporidiosis also can lead to death in the severely immunocompromised, especially those affected by HIV/AIDS. This protozoan is transmitted in the form of oocysts: very tiny egglike structures containing four sporozoites (young parasites) each that attach themselves to the epithelial mucosa (tissue coating the surface) of the small intestine. The oocyst itself is somewhere between 4 and 7 microns in average diameter. Thus, most modern filtration schemes may not adequately screen these out of city water systems. Even more problematic is the fact that this organism is resistant to chlorine (chlorination is a common water purification technique).

Oregon experienced another outbreak of diarrheal illness in 1992, this time due to a natural outbreak of cryptosporidiosis. Some 15,000 people were affected in Jackson County, Oregon. The largest recorded outbreak of this disease, however, occurred in 1993, when 403,000 people became infected with the *Cryptosporidium* organism in Milwaukee County, Wisconsin. Some seventy people died from the infection, most of these being HIV-positive individuals. This outbreak was caused by a large quantity of the parasite being drawn through the water treatment facility of the Milwaukee Water Works. Its exact source is still not known, although it is suspected that a large runoff containing waste from cattle, slaughterhouses, and humans flowed into Lake Michigan. From there, this contaminated water found its way to the water works, overwhelming its water treatment capacity.

Bioterrorists could possibly utilize a parasite such as *Cryptosporidium* to sabotage drinking water. The process involved in growing this organism and utilizing it as a BW agent, however, is probably too problematic to be worthwhile—either for a military or terrorist organization.

—Eric A. Croddy

See also: Bioterrorism

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PARATHION (METHYL AND ETHYL)

By 1944, the German chemist Gerhard Schräder and his team had already synthesized a number of organophosphates that had potential for commercial use as insecticides, but some (e.g., tabun and sarin) were so toxic to mammals that these were given to the Nazi military authorities for development as chemical warfare (CW) agents (*see* Organophosphates). One particular type of OP compound, an organothiophosphate called parathion, was also synthesized in Schräder's laboratory. Since that time, parathion has been used as the generic name for the insecticide ethyl parathion (O,O-diethyl O-p-nitrophenyl phosphorothioate). Another closely related insecticide, methyl parathion (O,O-dimethyl O-p-nitrophenyl phosphorothioate) has been marketed under a number of trade names, including Parathion-Methyl, Bladan, and Metafos. Ethyl parathion has been trade named Parathion, E-605, Etilon, Fosferno 50, and Panthion in the United States, and it was trade named Thiophos in the Soviet Union.

Both the methyl and ethyl analogues of parathion inhibit the functioning acetylcholinesterase and are relatively toxic in mammals, but they require larger doses to cause injury or death when compared to the military nerve agents (e.g., sarin or VX). Due to safety concerns, ethyl parathion has been phased out in the United States since October 31, 2003, per agreement between its manufacturer Cheminova and the U.S. Environmental Protection Agency. The use of methyl parathion in the United States is, as of this writing in 2003, restricted to only selected applications for outdoor crop protection. Parathion has also been restricted or outlawed in several countries that once manufactured it in large quantities, including Russia, China, and India. Still, there is a risk that remaining and obsolete stocks of parathion might be used by terrorists or criminals in some sort of improvised weapon.

During the apartheid era in South Africa, parathion may have been utilized as an assassination weapon against political targets. In 2003, the U.S. Central Intelligence Agency (CIA) mentioned parathion among other possible toxic chemicals that could be utilized by terrorists, including al-Qaeda. A CIA pamphlet notes: "Organophosphate pesticides such as parathion are in the same chemical class as nerve agents. Although these pesticides are much less toxic, their effects and medical treatments are the same as for military-grade nerve agents" (CIA, p. 4). Although essentially this statement is true, caregivers should be aware that the treatment for insecticide poisoning is actually somewhat different from those of military nerve agents. For example, in the case of insecticide poisoning, the required dosages of atropine can be substantially higher and longer term than, say, for sarin. As with other toxic OP compounds, exposure to significant amounts of parathion can lead to dizziness, sweating, blurred vision (pinpoint pupils), respiratory distress, nausea, convulsions, and possibly death.

—Eric A. Croddy

See also: Amiton (VG); Nerve Agents; Organophosphates; V-Agents

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PERFLUOROISOBUTYLENE (PFIB)

Perfluoroisobutylene (PFIB) is an industrial gas, most often produced as a by-product from the production of Teflon (polytetrafluoroethylene). PFIB has also found uses as an intermediate in some industrial processes, including etching for semiconductor fabrication. The cause of "polymer fume fever," PFIB has the potential to be an asphyxiating weapon, causing pulmonary edema even at very low concentrations. The high toxicity profile of PFIB (about ten times as toxic as phosgene) and its wide availability have made this compound a Schedule 2 toxic substance (an industrial chemical controlled to prevent its proliferation) in the Chemical Weapons Convention (CWC).

Like phosgene gas (carbonyl chloride), PFIB has a latency period between exposure and symptoms. Although toxicity data are sparse, in humans this latency period is estimated to be between 1 and 4 hours before signs of pulmonary edema manifest themselves. Because of PFIB's high toxicity and the fact that it could "break" protective filters used by military forces, some have speculated that the Soviet Union (and perhaps other countries) once weaponized PFIB. It was therefore brought to the attention of the Conference on Disarmament in 1989 by the United Kingdom, and PFIB was subsequently entered into the CWC. PFIB produced as an off-gas from incendiary fires or other heat sources is also a potential hazard, as militaries around the world often employ Teflon in fibers, tarpaulins, and other materiel.

—Eric A. Croddy

See also: Choking Agents (Asphyxiants)

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PHOSGENE GAS (CARBONYL CHLORIDE)

Not to be confused with phosgene oxime, phosgene gas (carbonyl chloride) is a classic lung irritant (choking gas) first used in World War I. The British chemist John Davy (1790–1868) is credited with having synthesized phosgene by combining carbon monoxide and chlorine in the presence of light, hence the name (*phos* = light, *gene* = born of).

Because of Germany's rapidly growing chemical industry, which existed well before World War I, there was already large capacity for phosgene production as a dye intermediate. The first known battlefield use of phosgene occurred on 19 December 1915 at Nieltje, in Flanders (Belgium). Here the German military combined phosgene and chlorine gas, releasing 88 tons of these from cylinders. Augustin Prentiss reported that this attack caused 1,069 wounded and 120 fatalities (Prentiss, p. 155). Used throughout the remaining years of World War I, with the advent of protective masks (respirators) phosgene became less and less effective.

The typical course of phosgene poisoning is delayed up to 24 hours. Phosgene, upon being inhaled, reacts with vital proteins, setting off a chain of events that disrupt the delicate tissues in the lungs. Battlefield injuries caused by phosgene were often insidious, as the following description by a World War I contemporary relates: "There are records of men who have undergone a phosgene-gas attack and who seem to have suffered slightly, but have died suddenly some hours later upon attempting physical effort" (Prentiss, p. 156).

Phosgene has a toxicity about ten times that of chlorine gas. Of the chemicals used during World War I, phosgene was particularly deadly, killing some 80 percent of its victims. However, it did not prove to be nearly as effective as mustard for causing large numbers of casualties (that is, dead and wounded) across the board.

A Schedule 3 industrial chemical regulated by the Chemical Weapons Convention (CWC), phosgene continues to be produced in large quantities (millions of tons per year) in the modern chemical industry. The diversion or sabotage of phosgene could pose a risk by its use in chemical terrorism. In 1994, there was an instance in which terrorists of the

Aum Shinrikyo attempted to assassinate a Japanese reporter (Shoko Egawa) by piping phosgene through the mail slot in her apartment door. The victim of the attack suffered no permanent injury, however, due to an insufficient concentration of gas.

—Eric A. Croddy

See also: Choking Agents (Asphyxiants); World War I

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PHOSGENE OXIME (CX, DICHLOROFORM OXIME)

Phosgene oxime (CX) appears often in the military chemistry literature, but in practice it is a relatively obscure chemical warfare (CW) agent. Phosgene oxime (not to be confused with phosgene gas, that is, carbonyl chloride) is also known as dichloroform oxime. Not to be confused with phosgene gas (carbonyl chloride), the basic formulae for phosgene oxime and related compounds were first discovered in 1894 by R. Nef and J. U. Scholl. Phosgene oxime was also synthesized by German chemists in 1929. Although the Soviet Union and Germany had researched this compound for possible use in chemical weapons before World War II, the United States military was largely uninterested, as its scientists (incorrectly) believed it had little to offer as a CW agent.

Phosgene oxime generally falls into the category of vesicants or blister agents, but this is mostly out of convenience. In contrast to sulfur mustard, another vesicant, phosgene oxime has little or no latency period, and its mechanisms of injury are not well understood. Small amounts of phosgene oxime cause painful irritation 5–20 seconds after exposure to unprotected skin. Perhaps phosgene oxime is better thought of as an urticant or nettle gas, having an effect similar to the painful effects of the stinging nettle plant. Although its structure is different from phosgene gas, phosgene oxime does share some of its properties as a lung irritant, in addition to its extremely irritating effect on the skin. According to Siegfried Franke, a "rash appears on the skin without the whole body's having come into contact with the substance. It is very intensive, unpleasant, and distracts the victim completely from his tasks. In general the itching effect of the aerosols begins on the hands and face and then spreads over the whole surface of the body" (Franke, p. 165).

A colorless, crystalline solid, phosgene oxime would likely be delivered as a thermal fog for battlefield use. There are no confirmed reports, however, of phosgene oxime ever having been used in warfare. In the chemical weapons literature, phosgene oxime has been used with other chemicals, including mustard or perhaps VX, to give these agents an increased penetrative ability. Phosgene oxime is also noteworthy for its ability to penetrate protective clothing—including rubber—faster than other CW agents.

There are probably few substances in organic chemistry that exert such a violent effect on the human body as phosgene oxime. Although not a true blister agent in the sense that its effects on the skin are different from mustard or lewisite, phosgene oxime produces an almost immediate and extremely painful irritation to the skin, eyes, and respiratory system. Some sources indicate that a full body rash can result from even limited contact with phosgene oxime, including the production of wheals. Sores and necrotic lesions on the skin require extensive time to heal, and, as with other blister agents, skin damage done by phosgene oxime can serve as focal points for opportunistic infections. Long-term effects of phosgene oxime have also been described, with injuries to the skin lingering for up to a year. As in the case of vesicants such as mustard, there is no prescribed regimen for treating exposure to phosgene oxime other than decontamination, antibiotics to stave off infections, and other supportive care.

—Eric A. Croddy

See also: Vesicants

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PINE BLUFF, ARKANSAS

The chemical warfare arsenal established in 1941 in southeastern Arkansas, 8 miles northwest of the city of Pine Bluff, was originally a site for the manufacturing of magnesium and thermite (a metallic-based incendiary) munitions. Pine Bluff's mission expanded to include extensive production of chemical agents, storage for a portion of the U.S. chemical weapons stockpile that was manufactured off-site, and production of biological weapons and munitions. After the termination of the U.S. offensive chemical weapons program, Pine Bluff Arsenal became Pine Bluff Chemical Activity, a storage site for approximately 12 percent of the original U.S. chemical weapons stockpile. Construction of an incinerator to destroy those weapons was completed in 2002. Disposal of agent and munitions was slated to begin in April 2004 after a period of testing of the disposal process.

Pine Bluff Arsenal produced both conventional and chemical munitions. Chemical agent production and weapon filling capabilities were quickly added, allowing the facility to produce and weaponize millions of pounds of the blister agents mustard and lewisite. In addition to the mustard agent stored on-site, Pine Bluff's storage igloos (large, reinforced storage structures covered with earth) also include 90,000 M55 rockets filled with sarin, almost 20,000 M55 rockets containing VX, and some 10,000 VX mines. These had earlier been transferred from other military storage locations during the 1950s and 1960s, before President Richard Nixon halted the transport of chemical weapons in 1968. The Pine Bluff Chemical Disposal Facility will use the army's baseline incineration method to destroy 3,850 tons of chemical warfare agents. In addition to the agent production facilities located at Pine Bluff, the arsenal also produced a variety of chemical weapons-related equipment, munitions, and protective material. This mission eventually expanded until Pine Bluff became the sole location for repairing and rebuilding several types of gas masks as well as one type of breathing apparatus.

In 1978, the U.S. government chose Pine Bluff as the location for research into and production of binary chemical weapons. After Congress authorized the production of this new type of chemical weapon in 1985, the M-687 binary projectile was produced at Pine Bluff, and one of the two canisters used in the projectile was filled at Pine Bluff. (The other canister was filled at the Louisiana Army Ammunition Project.) When the United States signed the Bilateral Destruction Agreement with the Soviet Union in 1990, the Department of Defense discontinued the program.

Pine Bluff was also a central part of the U.S. biological weapons program. Originally called the X-201 Plant, the biological facility at Pine Bluff was finished in 1954 and renamed the Production Development Laboratories. Later, a virus and rickettsia production plant was added. Between 1954 and 1967, at least seven different biological agents were produced: *Brucella suis* (brucellosis), *Francisella tularensis* (tularemia), *Coxiella burnetii* (Q-fever), Venezuelan equine encephalitis (VEE) virus, *Bacillus anthracis* (anthrax), botulinum toxin (botulism), and staphylococcus enterotoxin B. Pine Bluff also produced and filled many of the munitions used in the U.S. biological weapons program.

In the 1960s, U.S. offensive biological weapons activities included not only antipersonnel weapons but also antiagriculture weapons. Wheat stem rust and rice blast disease were among those agents produced at Pine Bluff Arsenal. When the United States discontinued its biological weapons program after President Richard Nixon renounced these weapons in 1969, Production Development Laboratories became the National Center for Toxicological Research. It now conducts research to support the regulatory activities of the Food and Drug Administration. All the antipersonnel biological agents at Pine Bluff Arsenal were destroyed between 1971 and 1972. Biological antiplant weapons were destroyed in 1973.

—*Claudine McCarthy*

See also: Biological and Toxin Weapons Convention (BTWC); Chemical Weapons Convention (CWC); Demilitarization of Chemical and Biological Agents; United States Chemical and Biological Weapons Programs

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PLAGUE

Plague is one of the oldest diseases known to humankind. The first documented plague epidemic occurred in 542 B.C. in Egypt, and it spread worldwide within four years. This plague lasted 50-60 years, and probably led to the death of 100 million people. The second epidemic was from 1346 to 1356, causing 13 million deaths in China and 20–30 million deaths in Europe. The most recent plague epidemic began in 1894; it started in China and spread to Hong Kong, affecting 26 million people. The common name of the plague is "black death" because cyanosis (a bluish or purplish discoloration due to lack of oxygen in the blood) causes the victim's skin to darken during the terminal stage of the sickness.

There are two forms of the disease found in humans as well as animals: classic bubonic plague and pneumonic plague, the inhalation form of the disease. Bubonic plague occurs from an infectious flea bite, while person-to-person spread of plague is possible through infectious aerosols (such as those produced by coughing or sneezing). In a biological warfare context, pneumonic plague would present the greatest threat.

The bacterium that causes plague is *Yersenia pestis* (formerly *Pasteurella pestis*), a gram-negative (so-called because it does not absorb gram's stain) bacterium. Virulent plague bacteria secrete a variety of substances that protect them against the body's defenses, and are triggered with elevated temperature found in the body (37 degrees C). These so-called virulence factors include F1 and VW.

In bubonic plague, the disease begins with a flea and host life cycle. In total, about 340 species of mammals can be hosts for fleas, and thirty varieties of fleas can be transmitters of *Y. pestis.* Animals such as squirrels, prairie dogs, and other rodents can harbor plague. Fleas feed on infected animals, taking in a blood meal. Infectious material containing *Y. pestis* bacteria clog the upper gut (proventriculus) of the flea. When this occurs, the flea can no longer take in nourishment. Now desperately hungry, it attempts to bite other animals, including those usually not typically associated with fleas (including humans). In the course of biting, the flea may disgorge the bacteria-laden material into the wound, infecting

Plague has struck down whole populations since at least 430 B.C. (Corbis) the animal. When a host (such as a rat) dies, its infected fleas move to other, living rats and pass the disease along. When infected fleas bite a human, bacteria enter the dermal lymphatics (the draining system that handles foreign matter, including pathogens). The plague bacteria eventually reach the nearest lymph node, frequently in the groin due to the fact that fleas often bite at the lower extremities. This route of infection results in bubonic plague, presenting with swelling of the lymph nodes such as those in the groin after a 1–8 day incubation period. The term bubonic comes from the Latin and Greek derived term for groin (bubo). However, bites that occur in other parts of the body may result in swelling of the nodes found in the armpit or neck. Headache, chills, sudden fever and vomiting often follow. Without medical treatment bubonic plague has a mortality rate of 50 percent. Left untreated, bubonic plague may develop into systemic infection of the blood (septicemic plague), then to the pneumonic form (100 percent fatal without treatment). In the latter case, bacteria seed the lung, forming infectious material that can be exhaled as aerosolized particles.

When a person inhales *Y. pestis,* it becomes pneumonic plague. Infection by inhalation occurs between humans in natural conditions, but it is more rare than bubonic plague. This infection route is caused by sneezing and coughing with bloody sputum. Pneumonic disease has an incubation period of two to eight days. The onset of the symptoms includes malaise, high fever, chills, headache, and myalgia (muscle pain). Pneumonic plague usually causes more severe sickness than bubonic plague. Death from this form of plague is due to respiratory failure and septicemic shock.

Early diagnosis of the plague is important because early treatment is critical in saving the patient's life. Extreme caution must be exercised by caregivers because the plague is highly infectious.

Plague can be treated with antibiotics. Without treatment, the pneumonic plague mortality rate is almost 100 percent; thus early treatment is especially critical for pneumonic plague. Bubonic plague usually responds well to antibiotic treatment. Vaccines can also help in defending against plague. The vaccine made from killed plague cells is not considered to be highly effective against the pneumonic form of the disease. It is important to prevent the spread of plague at the source, notably through control of rodents and using insecticides such as DDT to kill the vector (fleas).

The Plague as a Biological Weapon

Yersenia pestis is one of the strongest candidates for biological weapons because it is easy to culture and therefore can be mass produced. Additionally, *Y. pestis* can form an aerosol, and infection by inhalation causes the deadliest form of plague, pneumonic plague. From the 1930s until 1945, the Japanese, under the command of General Shiro Ishii, developed plague as a biological weapon. They devised a porcelain bomb that contained many infected fleas. When the bomb hit the ground, the porcelain shell was shattered and the fleas were released into the surrounding environment to spread the disease. According to some reports, these bombs offered an 80 percent survival rate for the fleas loaded inside the munition. Until President Richard Nixon announced the termination of biological weapon preparation in 1969, the United States was also engaged in defensive as well as offensive research of plague as a biological weapon. In former Soviet days, several thousand scientists were involved in a plague project at ten different institutes. By the 1980s the Soviet Union had weaponized a so-called "super plague." American scientists, on the other hand, failed to successfully weaponize *Y. pestis* during the 1950s–1960s.

The inhalation route is a good means for spreading biological weapons. Pneumonic plague is contagious and can easily spread from person to person. According to a World Health Organization (WHO) estimate, there would be 5 million people infected and 150,000 deaths if only 50 grams of *Y. pestis* were spread into the air as an aerosol over a major metropolitan city. As previously mentioned, unless it develops into pneumonia from the septicemic form of the disease, bubonic plague is typically spread by flea bites.

In the United States, there is naturally occurring plague, with ten to fifteen cases every year, mainly in the southwest. The last urban plague epidemic occurred in the United States in 1924 in Los Angeles. Since then, plague cases have usually been sporadic and have mainly occurred in rural areas of the country. Therefore, any modern-day plague epidemic is likely to be a result of bioterrorism, not a naturally occurring outbreak.

Detection of the exact strain of plague used in cases of bioterrorism is extremely important. Naturally occurring plague is mainly studied at the Centers for Disease Control (CDC) Division of Vector-Borne Infectious Diseases in Fort Collins, Colorado. To deal with the eventuality of a bioterrorist attack, the CDC lab is making genetic maps of more than 1,000 plague strains. The plasmid (bacterial DNA) profiles on the map could be compared with intentionally released plague to facilitate the identification of the source and origin of any plague used. The effect of plague on people during a bioterrorist attack would vary depending on conditions such as weather, time of day, topography of the area, and delivery system (sprayed from an airplane or sprayed on the ground) at the time of release.

Countries—or plausibly terrorist organizations—could bioengineer plague bacteria to make them resistant to antibiotics and able to lodge deeper in the lungs, making the new strains more lethal than the normal plague. With the advancement of biotechnology, it is relatively easy to make antibiotic-resistant plague by inserting antibiotic-resistant genes into the plague bacteria.

One problem in combating bioterrorism is that the release of plague is not immediately detectable. One or two days after a terrorist attack, however, patients with pneumonic plague would start appearing. The incubation period for pneumonic plague is one to eight days. Therefore, if a large number of pneumonic plague victims were observed within a short time span, a bioterrorist-related outbreak could be suspected. Alternatively, if it were a natural epidemic outbreak, the occurrence of the disease would usually spread over a longer period of time.

To improve consequence-managing capacity in the event of an attack, the U.S. Department of Justice conducted a simulated exercise of plague outbreak due to bioterrorism in Denver, Colorado, from May 20 to 23, 2000. The exercise gave valuable lessons, and the following conclusions were reached:

1. Political leadership in the decision-making process was critical. The process of decision making by conference call was highly inefficient and led to indecision and significant delays in taking action.
2. Assignment of priorities for the use of scarce resources and implementation is important. An antibiotic distribution plan should be improved in case of bioterrorism attack.
3. Facilities for drugs and medical equipment were inadequate and should be expanded.

—*Anthony Tu and Eric A. Croddy*

See also: Bioterrorism; Unit 731; Vector

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PLASTICIZED EXPLOSIVES

Plasticized explosives (or simply plastic explosives) is the term that describes the formulation of high explosive compounds—such as RDX (Royal demolition explosive)—in a form that is easily shaped for a variety of civilian and military uses. Some of the more popular forms of plastic explosives, such as C-4 and Semtex (made in the Czech Republic), have been widely used in terrorist attacks since the 1960s. With regard to weapons of mass destruction, as we have seen in the Oklahoma City bombing (1995), cheaply and mass-produced explosives such as ANFO or TNT (trinitrotoluene) could be used to kill large numbers of people and destroy entire buildings. Due to their relatively high expense and more specific roles, plastic explosives are therefore more likely to be found as triggering mechanisms or in smaller-scale attacks.

—*Eric A. Croddy*

See also: Ammonium Nitrate Fuel Oil (ANFO); TNT

POINT SOURCE

A device that disperses chemical, biological, or radiological (CBR) contamination from a single stationary location is known as a point source, the other major form of delivery being known as a line source. CBR agents are typically disseminated as an aerosol, gas, powder, liquid, or vector. Dissemination can be achieved by a variety of delivery mechanisms, including sprayers, bombs, bomblets, and missiles.

The term *point source* is generally associated with CBR agents that are released into the atmosphere as an aerosol or gas, but it can be applied to any combination of dissemination modes and mechanisms. For example, a bomb might explode, releasing an agent in the form of an aerosol into the atmosphere. Or, a 55-gallon drum may discharge a slow, steady stream of agent into a reservoir. In both of these cases, the agents have been dispersed from point sources. The motivation for classifying a source as point, line, or area arises from the need for understanding the spatial and directional characteristics of CBR contamination. This information is further used to develop vulnerability assessments and prepare emergency response plans.

There are numerous historical examples of CBR agents being deployed from a point source. One of the earliest recorded uses of CBR agents occurred in the fourteenth century when Tartar warriors launched plague-infected corpses over the city walls of Kaffa during a siege of the city. Although it is likely that infected rats were the likely cause, the plague-infected corpses were intended as a vector to disseminate the disease. As this strategy was employed at a single, confined geographic location (Kaffa), in a sense the entire city became a point source for the plague (*see* Kaffa, Siege of). As another example, in 1979, the Soviets accidentally released anthrax from a military compound in Yekaterinburg (this was known as Sverdlovsk incident). Again, as the agent was released from a single, confined, geographic location, the military compound is considered to be a point source for the anthrax (*see* Sverdlovsk Anthrax Accident).

An agent released into the atmosphere is affected by meteorological conditions: temperature, pressure, wind direction, and wind velocity. Atmospheric releases are either a continuous plume or an instantaneous discharge (puff). Most releases will be of a short duration because of the constraints on the total available mass of the CBR agent. If the total time of release is much less than the transport time between the source and downwind receptor, then the cloud is best modeled as an instantaneous release. Atmospheric effects diffuse a CBR cloud as it moves downwind from the source and generally form a cloud that is roughly one-third as wide as it is long. The cloud is carried downwind, spreading at a 30-degree angle to either side of the wind direction. Average casualty rates for unprotected populations can be predicted if information on the agent, distance from the point source, and wind speed are known. The exposure hazard is a function of both the CBR agent's concentration and the duration of exposure to the agent.

Recent trends in research and development have focused on improving wide-area, long-range, standoff, and remote agent detection systems that can increase early warning time and assist in consequence management.

—*Robert Sobeski*

See also: Aerosol; Biological Warfare; Inversion; Line Source

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PORTON DOWN, UNITED KINGDOM

The Chemical and Biological Defence Establishment of the British Ministry of Defence (MoD) is situated at Porton Down, a 7,000-acre site on the Hampshire-Wiltshire border in the Test Valley and Salisbury districts of southern England. Porton Down was established in 1916 as a top-secret chemical weapons test center. During World War II, its scientists began researching biological weapons, which became top priority during the Cold War. The United Kingdom relinquished its offensive chemical and biological weapons (CBW) capability in 1956 due to cost considerations and publicly admitted its existence in the 1960s. Since the end of World War I, over 23,000 people have taken part in experiments at Porton Down, some of these including human volunteer experiments involving chemical and biological agents. More than 300 ex-servicemen claim to have suffered disabilities, ranging from breathing difficulties to kidney complaints, as a result of tests carried out at the center.

Today, Porton Down conducts research and development on CBW defensive measures in four areas: hazard assessment, detection/identification, protection/decontamination, and medical countermeasures. It also provides expert advice to the United Nations, including the UN Special Commissions on Iraq. Current research includes biochemistry and inhalation toxicology (toxicity of gases, vapors, and aerosols of chemicals); full facilities for histopathology, including light and electron microscopy; drug evaluation; vaccine research; physiology; surgical and materials specialization; biological containment suites for dangerous pathogens (airborne infections); containment facilities for toxicological studies; an outdoor laboratory licensed for chemical trials; chemical laboratories for hazardous and supertoxic chemicals; vapor and particulate filter testing and evaluation; ultra-trace analysis of organic materials in media; and biological and chemical munitions disposal.

With 3,000 employees, Porton Down was retained as a government agency and was renamed the Defence Science and Technology Laboratory (DSTL) following government restructuring in 2001. It was empowered to develop and evaluate new technology to provide solutions for civil and military customers worldwide. In this capacity, it manages chemical and biological defense research programs as well as carrying out key functions relating to the overall integration of the results of the U.K.'s defense science and technology programs. DSTL Porton Down conducts research at the defense systems level and conducts management of international research collaboration. At the height of the U.K. foot-and-mouth disease epidemic in 2001, Porton Down also provided fast-track advice on cull disposal options for infected carcasses.

Porton Down is one of twelve laboratories worldwide designated to analyze chemical samples collected by inspectors implementing the 1997 Chemical Weapons Convention (CWC), the first arms control treaty that introduced a verifiable ban on an entire class of weapons of mass destruction. In other activities, the DSTL Porton Down Balkans Operation Support Group helped the scientific community to support the military during the conflict in Kosovo in 1999. Research agreements with the United States account for around one-half of Porton Down's collaborative research and development work. This collaboration includes the Atmospheric Dispersion Model for risk analysis of chemical and biological terrorism. In collaboration with Australia, DSTL Porton Down also developed and deployed support security operations for the 2000 Olympic Games in Sydney.

The Porton Down Biomedical Sciences Department provides the U.K. MoD with the science base for the development of effective medical countermeasures for chemical and biological agents, as well as ballistic countermeasures for military personnel. Its research efforts focus on expedient surgical approaches; vaccine development; and the fields of microbiology, biochemistry, genetic manipulation, and microbiological containment. Other developing capabilities include drug evaluation, toxicology, pharmacology, physiology, behavioral sciences, trauma and surgery, and animal breeding.

The environmental sciences department provides a science and technology platform to enable the Ministry of Defence to manage, monitor, and control biological, chemical, and radiological hazards and to dispose of abandoned chemical weapons safely through secure transport and storage. It also plays a key role in providing a nuclear accident response capability. Porton Down serves as the U.K. authority in radiation physics, dosimetry (radioactive detection metrics), and measurement. It can conduct environmental assessments and surveys of chemical, biological, and radiological (CBR) contamination. It conducts range trials capability for testing and evaluation of defenses against CBR agents. The energetics (physics) department and detection department conduct research and development of sensors and systems for detection of chemical and biological (CB) agents and explosives, along with CB hazard assessment and consequence management.

Porton Down is the U.K.'s designated laboratory under the CWC and the national laboratory for CB attack confirmation. Its capabilities include physicochemical techniques through the use of chemistry and solid-state sensors for detecting CW agents, microbiological sensing techniques, and CB hazard assessment. Facilities at DSTL Porton Down include exposure chambers, and its scientists study bioremediation dispersion modeling and validation. Porton Down also evaluates the role of public health, environmental protection, and nongovernmental organizations in reducing the CBW threat.

There is an integral radiological protection service within Porton Down that is the prime source of radiation protection advice for the Ministry of Defence. This Demil section conducts research into the protection of individuals involved with radioactive materials, such as routine protection of patients in hospitals and during dentist surgeries from radiation sources (tracers and X-rays), surveying battlefields for depleted uranium (DU) munitions, and establishing the whereabouts of counterweights used as ballast in aircraft (also made of DU) following plane accidents.

The Demil section is also responsible for the assessment of highly contaminated environments and for the sampling, analysis, removal, transport, and disposal of extremely hazardous and toxic materials and for the Ministry's chemical weapons demilitarization. It is thus involved in environmental monitoring in Russia; the disposal of hazardous chemicals in the Far East; and battlefield cleanup in Europe. The knowledge services department provides information products to support the defense community. Its publications include Defence Reports Abstracts and Defence Technology Alerts (the latter being classified), which comprise three-quarters of a million reports dating back to World War II.

—Glen M. Segell

See also: Gruinard Island; United Kingdom: Chemical and Biological Weapons Programs

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PRECURSORS

Compounds that precede the final product in a chemical reaction are called precursors. In the case of preparing toxic chemicals such as chemical warfare agents, chemical precursors are usually easier to obtain than the final toxic compound itself. To control the distribution of a particular toxic compound (such as VX nerve agent), it is essential to ban the sale of its precursors too, especially those chemicals that are closest in the chemical reaction steps to the final product.

This can be problematic, however. For example, sarin, a potent nerve gas, can be prepared from phosphorous trichloride, or PCl_3, which is usually the starting compound. PCl_3, however, has many other commercial uses, so authorities would not necessarily be alerted by its purchase. The 1993 Chemical Weapons Convention (CWC), therefore, puts PCl_3 lower on the list as a Schedule 3 precursor for regulation of export and manufacture. A Schedule 1 precursor, on the other hand, such as difluoromethylphosphonate (DF) is a key precursor to producing nerve agent (sarin or soman). As there is no industrial use for DF, and it is a highly useful substance to form the final nerve agent itself, the CWC has essentially outlawed its production (except in small quantities for defensive or peaceful purposes).

As in the case of PCl_3, some chemicals are easier to regulate than others as potential precursors for chemical weapons. Isopropyl alcohol, for example, when added to DF forms sarin nerve agent. However, isopropyl (rubbing) alcohol is found nearly everywhere, from industrial processes to the bathroom medicine cabinet. Little good would come of over-regulating this useful chemical that is sold and produced nearly everywhere. As a consequence, isopropyl alcohol is nowhere to be found in either the CWC schedules of precursors or the Australia Group (AG) list of chemical substances for export control. However, another chemical, pinacolyl alcohol, is listed in the CWC as a Schedule 2 precursor, as well as in the AG list of controlled chemicals. This is because pinacolyl alcohol has been used in the past to produce soman nerve agent, and in the commercial industry pinacolyl has very few common uses other than specialized research or in certain specialty areas (such as in pharmaceuticals). Therefore, it was easier to regulate this chemical without having to overburden the industry.

—Anthony Tu and Eric A. Croddy

See also: Chemical Weapons Convention (CWC); Dual-Use

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PROTECTIVE MEASURES: BIOLOGICAL WEAPONS

Biological agents are difficult to defend against, primarily because this form of attack is difficult to detect before exposure. Most biological agents have a delayed manifestation of symptoms, ranging from hours in the case of toxins to days or even weeks for bacterial and viral threats. During this delay, in the case of contagious diseases such as smallpox, airborne pathogens are possibly being passed from one person to another. Although protective suits and masks can prevent infection from biological agents, it is difficult to detect biological agents with sensors or alarms that give enough warning for personal protective measures to be put into place. It is therefore important to adopt protective measures in advance if there is a known chance that a biological agent is present. Employing protective measures before a biological attack occurs, however, will depend heavily on intelligence assessments. Ultimately, advanced research and development in the area of immunotherapy—that is, vaccines—as well as antimicrobial medications will provide the most effective protection against biological attacks.

Protecting against biological agents rests primarily upon protecting the airways from infectious particles. In a purely biological threat environment, covering the mouth and nose with any barrier to keep out particles of a size roughly between 1 and 10 microns is usually sufficient. The biological toxin of the trichothecene mycotoxin family is dermally active; however, all other biological threats are posed mainly by inhalation or ingestion, in which case the protective mask alone can prevent biological casualties.

Laboratory personnel have depended on protective clothing and equipment for years. The military has also been perfecting its defenses ever since the threat of biological weapons became a serious concern during Operation Desert Storm in 1991. The infection risk for nonmedical and nonmilitary personnel is greater because they do not operate in a controlled environment and they do not possess the advance warning devices that may be available to militaries. Still, unless humans or sentinel animals show obvious signs of infection, even military personnel still find it difficult to reliably detect biological warfare agents. Even when detected, some infections could be mistaken for naturally occurring diseases rather than recognized as a planned attack. Therefore, considerable time may elapse before it is realized that a biological attack has occurred.

Immunizations and prophylactic medications (such as antibiotics for bacterial agents) are the first line of defense available to both civilians and military personnel. For immunizations to be effective, the threat or agent must be known, there must be a vaccine available to fight off infection, and there must be time for the vaccine to take effect. (Time is also important because some vaccines must be administered in stages.) Providing vaccines to military personnel is much easier than providing the inoculations to civilians: The armed services are a relatively small and intensely observed population, and it is therefore easier to keep track of immunizations and to update shot records. The civilian population must usually take it upon themselves to seek out available vaccines and to maintain their personal health. For the armed services or civilians, however, personal health maintenance is necessary to improve the survivability of a biological attack, and up-to-date immunizations reduce the chances of becoming a casualty of a biological attack. It is important to understand what diseases or viruses are prevalent in areas of concern, and intelligence assessments should warn the armed services of biological hazards that they may come into contact with. There are many biological warfare agents, however, that have no cure or vaccine.

Collectively, buildings can be protected to a degree from a biological attack. Physical security is important; however, if an attack were to occur, special airflow and filtration systems can limit the number of people infected. HEPA (High Efficiency Particulate Air) filters capture 99.97 percent of particles 0.3 microns in diameter or larger. ULPA (Ultra Low Penetration Air) filters capture very small particles, 99.999 percent of particles 0.12 microns in diameter or larger. In the case of biological threats, the particles of most concern are usually those between about 1 and 10 microns in diameter, sometimes larger. Adequate filtration systems, together with increased physical security, can make a building a less attractive target for biological attack because the success of the attack would be minimized.

Finally, before an attack occurs, one should be aware of local response procedures for a biological attack and should have a plan, just as one would for a fire or a medical emergency. A rapid response to a biological attack will limit the amount of casualties and increase the chances for those infected to be treated promptly.

Provided that civilian and military personnel had knowledge that a biological hazard existed and knew the type of biological agent, personal protective equipment could prevent contamination and infection. Most biological weapon agents are not easily spread from person to person; the more contagious agent threats are smallpox, plague (pneumonic), and some hemorrhagic fevers. By contrast, anthrax bacteria are not likely to be contagious unless there is gross contamination.

Protective Clothing and Equipment

There are four types of biological safety postures, which differ based on the type of agent present and its virility. At a minimum, those who first come into contact with victims of a biological attack should use impermeable (surgical type) gowns, oral-nasal masks, face shields or goggles, and surgical gloves. It is important to wear a protective mask, to keep the clothing buttoned, and to treat any unknown agent as if it were a chemical agent requiring the highest degree of skin and respiratory protection. The types of suits and masks and the levels of protection they provide follow.

Biosafety levels describe the type of protective clothing worn and the equipment and room attributes that must be present to provide that level of protection from biological agents. Biosafety level 1 (BL 1) provides the lowest level of protection. It provides a basic level of containment and can be effective when the microorganisms present are not known to cause disease in human beings and when the potential hazard to laboratory personnel or the environment is minimal. Gowns and gloves are used, and eye and face protection may be required if there is a splash potential. There should be a sink for washing hands in a laboratory environment, and work areas should be kept sanitized. When a sink is not available, some other method for washing hands should be employed.

Biosafety level 2 (BL 2) is required when there is a moderate potential hazard to personnel and the environment. Immunization or antibiotic treatment should be available for the infectious agent. Gloves and lab coats should be used, mechanical devices should be used to prevent contact with blood or other bodily fluid that may hold the infection, and care should be used to not injure oneself with sharp needles, broken glass, or other sharp objects that may be contaminated. Immunizations are important for protecting against infection from level 2 agents. Equipment such as safety cabinets and eye and face protection should be used for protection against splashes and aerosols. (A safety cabinet is a work area that is usually attached to a ventilation system and is enclosed on all sides except for the front to limit splashing and spills.) An eye wash station and equipment to sterilize protective clothing, such as an autoclave, should be available. (An autoclave uses pressurized steam to sterilize equipment and clothing.)

Biosafety level 3 (BL 3) is required when the potential hazard is an infectious agent that can cause serious or lethal disease from inhalation of the agent. A mask that provides respiratory protection is necessary in addition to face protection, as well as coveralls for the body and gloves for the hands. To the extent possible, it is necessary to seal off the contaminated area using double-door entries and other secondary barriers. Safety cabinets or glove boxes (fully enclosed work areas attached to a ventilation system) should be used as work areas. For glove boxes, protective gloves are built into the work area so that work can be done with level 3 biological agents.

Biosafety level 4 (BL 4) is required for work with dangerous and exotic agents that pose a risk of being transmitted by aerosol and are life-threatening, and for which there is no available vaccine or reliable treatment in the case of infection. The BL 4 suit provides complete isolation from the infectious material. It is a full-body suit including gloves, boots, and protective mask that is airtight with a positive pressure air supply, ensuring that any potentially hazardous particles will be expelled outward from the wearer. The air supply may be an individual tank or may be sourced from a wall unit. Containment of the infected area is most important when level 4 agents are present. In addition to the equipment used for BL 2 and BL 3 facilities (safety cabinets and glove boxes), work areas should be sealed with double entry doors, and these should be airlocked (sealed with air pressure). There should be dedicated HVAC (heating, ventilation, and air conditioning) and air filtration units. The walls and floors should be nonporous and water-resistant, and a shower and changing room should be attached to the contaminated area. When work is being done outdoors, every effort should be made to replicate these laboratory conditions with modular units constructed around the contaminated area.

Actions Following a BW Attack

Once an attack has occurred, determining what level of protection is needed is vital. The infectivity, virulence, and toxicity level of an agent will determine what types of protective measures should be taken to prevent the spread of disease after an attack. Not all biological agents pose a threat of being transmitted to another individual; however, workers should still take precautions such as barrier nursing (wearing protective clothing and never coming directly into physical contact with an infected person) and isolation (separating nonaffected individuals from contaminated victims of a biological attack).

Decontamination is an integral step in preventing further contamination after a BW attack. All contaminated clothing should be placed in an airtight, impermeable bag until the clothes are laundered in hot water and bleach or until they are autoclaved. Soap and water or a solvent should be used to wash away the biological agent from the victim's body. Ideally, all equipment or surrounding objects should be washed with soap and water or solvent as well. Some environmentally safe chemicals may be used to disinfect biological toxins.

Some medical procedures can be taken after an attack, depending on the type of biological agent used. Specific therapy can be used for many biological agents, with drugs that diminish, alter, or reverse the agent's effects. General supportive measures are used to make a victim comfortable; these do not cure the victim, but they can help ameliorate symptoms. For instance, a biological agent may cause respiratory distress; artificial ventilation is a supportive therapy that may even be crucial for survival after some attacks, such as botulinum toxin poisoning.

Advance Warning

With regard to advance warning and preparedness against a biological weapon attack, intelligence is the key. Medical countermeasures are not always available or effective. Communication networks and response plans must be in place to maximize early warning. Good intelligence must alert populations to specific threats so that personal protective measures can be employed. Information on specific biological threats can be the greatest protective measure; when the threat is known, personal protective measures and medical countermeasures become most effective.

—Stephanie Fitzpatrick

See also: Biological Terrorism: Early Warning via the Internet; Vaccines

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PROTECTIVE MEASURES: CHEMICAL WEAPONS

No longer a threat limited to the battlefields of foreign conflicts, chemical and biological weapons now present a threat to civilians and government personnel as well as to the armed services. At varying levels of sophistication, terrorist organizations, state actors of concern, and even certain individuals may develop chemical warfare (CW) agents and the munitions to deliver them. By leveraging modern information technology and widening trade routes to smuggle chemical precursors—even the chemical weapons themselves—terrorists and rogue states are able to move these items across borders without much likelihood of being detected. It is therefore necessary to understand CW protective measures, both personal and collective, that can be used in the event of a chemical attack.

The first basic concept is contamination avoidance. By means of reconnaissance and through the use of detection devices, personnel are naturally less likely to become chemical casualties by avoiding toxic exposures in the first place. Should these measures fail, a range of personal protective equipment has been developed to prevent chemicals from coming into contact with the body through inhalation or exposure to skin. Finally, decontamination through the physical and/or chemical neutralization of agents can be used to mitigate chemical threats.

Types of Protective Suits

There are different levels of protection available. In the civilian context, Level A suits provide the greatest level of protection. A Level A suit is airtight and covers the entire body. It includes boots and gloves, a pressure-demand (use of air pressure to create a better seal) full-face mask with a self-contained breathing apparatus (SCBA), and a communication system (usually a two-way radio) that are all contained within the suit. This ensemble protects against vapors and should therefore be used when the highest level of protection is needed to protect the skin, eyes, and respiratory system, especially when the chemical agent is unknown. Level A protection is needed when there are high concentrations of vapors, gases, or particles and should be used when the possibility of exposure to skin is great and the contaminated environment is poorly ventilated.

The Level B suit offers high protection for the respiratory system but less in the way of skin protection. This suit will have the pressure-demand full-face mask with SCBA, but it includes only chemical-resistant clothing rather than an airtight suit. The chemical-resistant clothing consists of coveralls, gloves, boots, and sometimes a hard hat, as well as two-way radios. The Level B suit should be used when the chemical is known and is not harmful or absorbed through the skin, or when the concentration requires respiratory protection but only limited skin protection. The Level B suit is usually sufficient for these chemicals, whether in liquid, gas, or vapor form. Emergency teams that deal with hazardous materials (hazmat) incidents most often use Level B suits.

A Level C suit is used when a substance has been identified and it is known that air-purifying respirators alone will provide adequate protection. A Level C suit will have a full-face shield or a half mask, and requires only an air-purifying respirator (no SCBA), and hooded, chemical-resistant clothing such as coveralls, gloves, boots, and sometimes a hard hat and two-way radios. The Level C suit can be used when direct contact with the chemicals will not affect the skin, or when the chemicals will not be absorbed into the skin.

The Level D suit provides only minimal protection. This type of suit is worn when there are no known atmospheric hazards, but when work-related activity could produce splashes, immersions, or the potential for chemical inhalation. The ensemble in this case might consist of coveralls, a lab coat or other outer layer for minimal protection, and possibly a face mask such as a surgical mask to minimize inhalation of nonlethal but hazardous chemicals.

Chemical protective clothing is designed to prevent chemicals from coming into contact with the skin. It is made from special materials and can be either permeable or impermeable. Impermeable suits are used for hazardous materials situations when the airtight feature of the Level A suits is required. Permeable suits have a charcoal lining to provide added protection. Military-issue protective clothing is usually permeable. Impermeable suits are less costly than permeable suits, but they are often disposable and only intended for one-time use. They are also extremely uncomfortable when worn for long periods of time in the field. Permeable suits can be used again, depending upon the overall quality of the garment and the nature of the activated charcoal layer. Impermeable suits have an increased level of heat buildup inside the suit, whereas permeable suits allow for some air transfer and are generally cooler to wear. Impermeable suits, however, can be exposed to water and can be used during decontamination operations, whereas water can decrease the overall effectiveness of permeable suits. The latter are more durable than impermeable suits, however, and are used for tactical operations and when extreme physical conditions are present, such as high temperatures.

There are several types of masks that can be used for respiratory protection in the case of a chemical attack. Escape masks have a hood and filter or air supply and are used to provide respiratory protection for a short duration, usually only long enough to evacuate from a suspected contaminated area. There are several problems with escape masks, however: It is difficult to communicate when wearing one, the face piece causes claustrophobia in some individuals, and it is difficult to maintain a tight seal around the face, allowing contaminants to enter the mask.

A negative-pressure respirator is the most common type of "gas mask." It provides Level C protection but is not recommended for situations in which the agent contaminant is undetermined or the concentration of agent in the air is unknown. Most importantly, there must be an oxygen level of at least 20 percent in the atmosphere in order to use a negative-pressure respirator. Communication will still be limited when wearing this type of mask, but voice amplification adaptors can be installed to enhance the ability to communicate.

Powered air-purifying respirators (PAPR) are similar to negative-pressure respirators, except air is supplied by a battery-powered pump that forces air through the filter in the face mask. This type of mask makes it easier to breathe and reduces heat buildup because of the stream of cool air filtering into the mask. However, there are several disadvantages: The hose that connects the blower to the filter can get in the way and may easily get caught on something, pulling the mask away from the face. The hose could also be damaged and the air supply cut off. This type of mask is heavy, the blower is loud, and the wearer's communication capability can be reduced.

A self-contained breathing apparatus provides the greatest level of respiratory protection. A SCBA uses a clean air supply from a tank or from a stationary oxygen source located near a work station. Although SCBA provides the greatest level of protection, the self-contained air supply does run out and must be changed. This can significantly disrupt operations. The SCBA units are also costly to purchase and expensive to maintain.

In most respects, respiratory exposure to chemical agents is usually more dangerous than skin exposure. However, in the case of some threats (e.g., VX nerve agent), skin exposure can be just as deadly. The overgarment/suit, gloves, and boots provide protection for the skin. There are different types of overgarments (one-piece, two-piece, hooded, etc.). A suit's level of protection is determined by whether or not it is fully encapsulating or non-fully encapsulating. Level A overgarments are airtight and fully encapsulating. Level B and C overgarments are non-fully encapsulating and offer less skin protection. Gloves capable of protecting against chemical agents should be made of butyl rubber or a similar substance, and the thickness of the glove will offer added protection but with a trade-off in hand dexterity. There should always be a balance between effective protection and maintaining the ability to perform daily activities in protective gear. When contamination is possible, individuals should err on the side of increased protection.

There are two types of footwear for chemical protection: booties that are part of the overgarment, or full boots that can be worn over shoes. Full boots worn over shoes provide the greatest protection. They are usually made out of a thick rubber and cover the foot and the bottom part of the leg. When worn with protective pants or coveralls, there is less chance for leaks to enter at the opening of the boot.

U.S. Military Force Protection

In the U.S. military, the doctrinal approach to chemical defense equipment in the field is referred to as the mission-oriented protective posture (MOPP). Defense levels are rated from MOPP I to MOPP IV, depending upon the severity of the threat. For example, at MOPP I, a battle dress overgarment (BDO) is worn to serve as some barrier against most agents, and M9 chemical detection paper is worn on the sleeves and near the ankles. Such a posture is for a chemical threat whose nature or severity is not yet determined. At MOPP IV, the entire body must be covered, using a protective mask, hood, and rubber gloves. The newer Joint Service Lightweight Integrated Suit Technology (JSLIST) protective overgarments incorporate a fabric surface layer that beads off liquid threats, and an advanced, activated charcoal layer using tiny beads to absorb toxic agents before they reach the skin. The M40 chemical-biological field mask, currently being used in the U.S. military, is another advancement, with improved fit, a seal around the face, and better visibility. The C2A1 filter canister consists of charcoal, filter elements to remove small particles (greater than 3 microns in diameter), and zinc to inactivate chemicals.

Personal protective equipment should be put on in a specific order so that the most critical areas are protected first. When first alerted to a contamination, the face mask and respiratory apparatus is donned first. The body's respiratory system should be protected first because chemicals have the greatest and most rapid effects when inhaled. Next, the greatest surface area of the body should be covered by putting on the overgarment. Then, the boots and gloves are put on, making sure that the overgarment's sleeves and legs are on the outside, so that chemicals cannot easily fall down into the boots and gloves. Finally, a hard hat or extra protection such as a splash guard apron can be put on for further protection.

Collective protection equipment will allow groups of people working in a chemical-contaminated environment to receive protection while limiting the need for personal protective equipment. Collective protection is necessary when an area is exposed to contamination for an extended period of time. There are modular rooms that can be assembled with filter units to eliminate contaminated particles and vapors from entering the room. There also are hybrid systems that use positive pressure and ventilation. Positive pressure reduces the amount of vapor contamination that enters a vehicle or room, and protective entrances on modular rooms provide separation between a contaminated and a protected environment. Decontamination procedures must be used before entering a protected environment. Chemical detection and monitoring alarms are another form of collective protection. They warn when an area has a significant level of contamination so that personal protective measures may be employed.

Decontamination

Decontamination is a secondary protective measure used to prevent the spread of contamination to others. Both equipment and personnel should be decontaminated. Chemicals can be removed physically or chemically (using other, nontoxic chemicals to deactivate harmful agents). Physical methods involve washing with soap and water or a solvent, vacuuming, brushing and scraping, absorption, and disposal of contaminated clothing and material used in the decontamination process. Physical methods can be used whether the chemical has been identified or not. Chemical methods are primarily used on equipment. This process uses some type of chemical reaction to render an agent ineffective and less harmful to the environment through disinfecting, sterilization, neutralization, solidification, or degradation.

When decontaminating people, all gross signs of contamination should be removed first by scraping, sweeping, or blotting, and then all clothing should be removed. Clothing that needs to be removed over the head should simply be cut off. Next, the person should remove all watches, eyeglasses, or other items and flush the eyes with large amounts of water. Next, the face and hair should be washed with soap and water and thoroughly rinsed. The person should then begin to wash the rest of the body starting at the neck and working down, so that any remaining chemicals will not be spread to the face and eyes, which have already been decontaminated. Personnel can then change into uncontaminated clothing.

Both personal and collective protective measures are essential to maintaining a protected environment. Familiarity with equipment and protective procedures can dramatically reduce the number of chemical casualties in an attack. Knowing, understanding, and training with personal protective equipment and collective protective equipment can truly be an effective defense against the use of chemical weapons.

—Stephanie Fitzpatrick

See also: Atropine; Bleach; Decontamination; Oximes; Pyridostigmine Bromide

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PSYCHOINCAPACITANTS

As chemical warfare (CW) agents and potential mass casualty weapons, psychoincapacitants are designed to render military personnel and other targeted individuals incapable of performing even the most basic tasks. The ideal psychoincapacitant does not cause death or permanent damage, and its effects are temporary, lasting long enough for the attacker to achieve tactical advantage on the battlefield. BZ (3-quinuclidinyl benzilate) was the only psychoincapacitant standardized by the U.S. military (1962). Other militaries, including Iraq and the former Yugoslavia, are also suspected of having developed BZ or similar agents. The Iraqi version was called Agent-15. The use of such CW agents is outlawed by the 1993 Chemical Weapons Convention (CWC), and the United States was thereby obligated to destroy all of its remaining stocks of psychoincapacitants.

A 1956 working paper written at the Operations Research Office at Johns Hopkins University identified several targets as being vulnerable to psychoactive chemical attack:

a. Attacks on key personnel to impair their judgment and lead to poor decisions at a critical time
b. Psychochemical attacks on the population of a city prior to attack by other means, to destroy effective protective measures and/or resistance
c. Attack on [Strategic Air Command] or other military organizations to impair or destroy effectiveness (Gardner, p. 2)

Unlike other CW agents, whose purpose is solely to injure and kill, a true psychoincapacitant does not cause significant harm among targeted individuals. Being nonlethal, psychoincapacitants can offer more flexibility in operations against enemy troops intermixed with civilians. To achieve a balance between potent action and low toxicity in humans, the chemical compound used must be safe enough to be absorbed in large doses without fatal consequences. Maintaining this margin of safety has proved to be extremely challenging during the course of research and development (R&D) of psychoincapacitants. Arguably, no "perfect" incapacitating agent has yet been discovered.

The United States Army, for example, researched many potential candidate psychoactive chemicals during the Cold War before finally settling on BZ (agent "buzz"). Even this compound had its limitations. Its effects were by no means immediate, requiring up to a few hours to manifest themselves following exposure. Like other compounds studied, BZ was to be delivered as an aerosol, in a device similar to military-type CS tear gas (riot control agent). This generated a large pall of smoke that was clearly visible to the enemy, and thus little tactical surprise could be achieved. And although it was decidedly less deadly than other CW agents in the U.S. arsenal, the side effects from large doses of BZ could be dangerous.

Finally, one has to consider the end result when considering use of a psychoincapacitant: will enemy personnel affected by a psychoactive drug become less or even more dangerous and unpredictable following intoxication? How will this affect operations to secure enemy prisoners of war (e.g., will prisoners become more violent, unruly, and unresponsive to commands)?

Background

Modern R&D efforts into utilizing psychoincapacitants as a means of warfare began mostly in the 1950s, a time when chemotherapy for psychological disorders was widely studied. Earlier examples of the use of psychoincapacitating agents in war go back almost 1,000 years. In his study on atropine—a chemical long known for its effects on both body ("dry as a bone, hot as a hare") and mind ("mad as a hatter")—a U.S. Army chemical researcher by the name of E. Goodman (1961) found that in 1040, Scottish armies "used wine dosed with 'sleepy nightshade' against the troops of Sweno, King of Norway" (quoted in Ketchum and Sidell, p. 289). Goodman also describes a battle during which belladonna (i.e., atropine and related substances) was used by the Bishop of Muenster during a 1672 siege of Greningen. In this case, however, unfavorable winds caused the belladonna (delivered in the form of grenades and other pyrotechnic projectiles) to blow back onto the attacking forces. Other examples from modern history include the inadvertent consumption of Jimson's weed, a plant that has belladonna properties, leading to delirium among troops.

From 1953 to 1973, the U.S. Army investigated the use of a number of chemicals that had potent but largely transient effects on human cognition and behavior, including the following:

- Depressants (barbiturates, opiates)
- Diliriants (BZ, other belladonna-like drugs)
- Stimulants (amphetamine derivatives, nicotine, etc.)

Many of the chemical substances in these categories seemed at first to hold promise as potential incapacitants. After all, most are used in medicine without excessive risk (albeit under controlled conditions), and some are used recreationally (with much less attention to their possible dangers). After these chemicals were studied in experimental animals (as well as human subjects), however, most were eliminated as viable candidates due to the fine line between their desired effects (temporary incapacitation) and permanent incapacitation (i.e., death). Lysergic acid diethylamide (LSD-25) at first seemed a promising psychoincapacitant because it had a thousandfold spread between what was needed for incapacitation and the lethal dose. However, its possible effect on the enemy might have been unpredictable, and in ways that may have been undesirable. (Would enemy soldiers not only manage to fire their weapons under the effects of LSD, but also become better shots?) Also, some individuals have had serious side effects (such as epileptic seizures) from relatively small doses of LSD.

Other chemicals investigated as possible psychoincapacitants included MDMA (popularly known on the street as ecstasy), technically a stimulant but having potent hallucinogenic properties. Phencyclidine (PCP or "angel dust"), tetrahydrocannibol (THC), and psilocybin have also been investigated for use in warfare or sabotage. But the anticholinergics, such as belladonna drugs (including atropine and scopolamine) traditionally derived from nightshade and Jimson's weed (among others), are the only drugs reliably causing sufficient delirium to incapacitate enemy troops while still being reasonably nonlethal.

Generally, the delirium induced by BZ involves hallucinations, including impairment of perception in terms of size and shapes; delirious "woolgathering" behavior (the pulling at clothing, real or imagined); and delusions played off others who also are affected by the drug. The psychological impact can be long-lasting (a day or longer) but resolves on its own. As with the other belladonna drugs, widened pupils, rapid heartbeat, flushed skin tone, and visual impairment are hallmarks of BZ intoxication. Administering a carbamate (e.g., physostigmine) can at least temporarily diminish the effects of belladonna-induced delirium, and such treatment can be used as a means to diagnose what is happening while reassuring the patient that the effects will eventually go away. Because these belladonna drugs shut down the sweat glands, the potential for hyperthermia—especially in stressful conditions of combat and field operations—is considerable, and body temperature should be closely monitored.

Another category of compounds, the opiates, has already been utilized in at least one recent counterterrorism operation in Moscow in 2002 (*see* Fentanyl). Although they are nominally included in the category of psychoincapacitants, it is uncertain whether opiates are safe enough to use in military-style operations. One advantage they have is that an antidote (Nalaxone or Narcan) is available to treat opiate intoxication. Although considered unfit for large-scale production or weaponization, opiate drugs such as fentanyl may in the past have had some applications in specialized warfare or covert operations. For example, the military use of fentanyl or similar drugs was considered for tactical roles in Vietnam. The intention was to isolate high-ranking individuals and temporarily knock them out while scattering away irrelevant logistical support personnel. The army could then bring these officers in for questioning. One of the plans was to utilize something along the lines of a tranquilizing dart with fentanyl or a related substance. In the end, however, the science advisor to General Westmoreland (commander of U.S. troops in Southeast Asia) did not approve of this venture, and only CS (a riot control agent) was ever employed in Vietnam.

In October 1997, the Israeli Mossad used fentanyl in what was either an assassination attempt or a snatch-and-grab operation that subsequently went awry. In this case, Israeli intelligence operatives (including one physician) traveled to Jordan. There, they followed Khalid Mishal, a Jordanian-based Hamas leader. The plan was to deliver fentanyl in a spray that would be absorbed through Mishal's ear, but Khalid Mishal was able to escape. Following the event, he was reportedly affected by the drug, requiring significant medical attention.

Current Uses of Psychoincapacitants

In the twenty-first century, the potential always exists for the use of psychoincapacitants in warfare (in 1995–1999, for example, Serbian armed forces allegedly used BZ against Bosnian Muslims, but this allegation has yet to be fully evaluated). The use of these potent chemicals in terrorism is also a possibility, but it is unlikely. It is much more likely that terrorists, if they were to go the trouble and expense of developing weaponized CW agents at all, would choose deadlier and more persistent chemicals (e.g., VX).

The CWC clearly prohibits the use of psychoincapacitants like BZ in war. Interest in so-called nonlethal warfare has triggered a response from critics in the arms control community that this will lead to CW under a different name. For example, a 2001 article from the Chinese military newspaper *Zhongguo Guofangbao* (*China National Defense*) refers to the cholinergic compound EA3834, which was researched by the U.S. military as an anticholinergic incapacitant. Its authors then decry so-called nonlethal weapons chemicals as being "inhumane." Although some have recently called for further clarification as to the legality of using nonlethal chemicals, the U.S. government believes that the current language in the CWC is sufficient. (BZ, for example, is explicitly scheduled as a proscribed chemical under the CWC lists of toxic chemicals, and its precursors are also controlled.) The U.S. government is not against banning psychoincapacitants, but is concerned that the prohibition might later be extended to tear gas. Thus, the U.S. government resists what it sees as a political movement toward outlawing the use of riot control agents (RCAs). Since 1975, the United States has reserved the right to use CS tear agents, for example, during combat operations under special conditions.

The Russian use of fentanyl (or a related compound) in 2002 against Chechen terrorists barricaded in a Moscow theater, although conducted as a domestic police action, highlights the problem of prohibitions on psychoincapacitants. On October 23, 2002, in the middle of an evening performance at a Moscow music theater, some fifty Chechen terrorists equipped with firearms and large quantities of explosives suddenly seized the venue, taking hostage 800 people inside. The terrorists threatened to kill the hostages unless Russia ended the war in Chechnya. Although the Chechen militants agreed to release some of the hostages during the first couple of days, their negotiations with the Russian authorities eventually stalled. Just before dawn on October 26, Russian special police units used an incapacitating gas based on the drug fentanyl to end the crisis. All of the Chechen militants were shot and killed as they slept, and most of the civilian captives survived. But although the operation was largely a success, at least 117 of the hostages died from the effects of the gas.

The fact that so many died because of poisoning from the gas has been the source of some controversy about how the entire operation was handled. But even while acknowledging that mistakes were made by the police, most Russians supported the action taken by Moscow authorities. The international community (including the executive body that governs the CWC, the Organization for the Prohibition of Chemical Weapons in the Hague) has not formally contested the Russian use of chemicals against terrorists on legal grounds.

—*Eric A. Croddy*

See also: Atropine; Fentanyl

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PYRIDOSTIGMINE BROMIDE

Pyridostigmine bromide (PB) was given as a prophylactic tablet during the 1991 Persian Gulf War to protect U.S. military personnel and some other allied forces in the event that Iraqi forces attacked them with the chemical nerve agent soman. The U.S. Food and Drug Administration had approved PB in 1955 for treatment of myasthenia gravis, a neuromuscular disease that causes muscle weakness and fatigue. However, when U.S. authorities approved PB for use in the Gulf, the approval was qualified as an investigational new drug: PB had not been formally approved for general commercial marketing as a nerve gas antidote. Since the war,

Pyridostigmine bromide (PB) can be used as a pretreatment for nerve agent exposure. (Orban Thierry/Corbis Sygma)

thousands of American, British, and Australian veterans of the conflict have reported health problems such as joint pain, headache, sleep disorder, memory loss, and fatigue. The veterans report these problems more frequently than those who were not deployed, raising the possibility that PB may be linked to Gulf War illnesses.

During the Persian Gulf War, coalition forces recognized that Iraq possessed nerve agents, including sarin, and had prepared them for use in rockets, bombs, and missile warheads. Recalling that Iraq had previously employed chemical weapons against Iran and the Kurds, coalition governments anxiously tried to prepare their forces to fight in a chemical environment, something they had not done in earnest since the First World War. It was not known whether Iraq had militarized the nerve agent soman, but because the Soviet Union had produced soman during the Cold War, and because of fears that Iraq may have acquired soman from Russian sources after the breakup of the Soviet Union, coalition troops were given PB to use for protection when the threat of chemical warfare was deemed high. After the Gulf War, Iraq was discovered to have weaponized the nerve agents sarin, cyclosarin, and perhaps tabun and VX, but it probably did not possess soman.

The Defense Department estimates that approximately 250,000 personnel took at least some pyridostigmine bromide pills during the Gulf War. (All U.S. troops were supposed to receive packets containing PB pills.) The PB was intended to be self-administered upon a unit commander's order. In some units, PB administration was carefully monitored, but in others, it was not. Troops generally did not receive adequate information about the possible side effects of the drug. Actual administration of the pretreatment was decentralized and not under direct medical supervision, so accurate assessments of actual PB use are difficult to obtain, because no specific records were kept of self-administered medications.

Medical science has not yet been able to explain many Gulf War illnesses; thus, some people wonder if troops were exposed to an agent or combination of agents that caused these illnesses. In addition to PB, the men and women who served in the Gulf War theater faced exposure to a wide variety of chemical and biological agents including smoke from oil fires, paints, solvents, insecticides, petroleum fuels, organophosphate nerve agents, depleted uranium, anthrax and botulinum toxoid vaccinations, and infectious diseases, in addition to psychological and other physiological stress. Authoritative studies have concluded that there is inadequate evidence to determine whether pyridostigmine bromide is associated with chronic adverse health effects.

—Peter Lavoy

See also: Carbamates; Gulf War Syndrome; Nerve Agents

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Q

Q-FEVER

Q-fever is a common global disease of wild animals and domestic livestock, especially sheep, cattle, and goats, caused by the bacterium *Coxiella burnetii.* Humans are usually infected with *C. burnetii* by inhalation of aerosols from infected animal products or of dust particles containing the spore form of the bacterium. In natural settings, the organism has low virulence (that is, produces less serious disease) for humans, with only half of all infected humans developing signs of illness. When disease develops, Q-fever has both acute and chronic forms, and the predominant clinical symptoms vary widely, making diagnosis difficult. The onset of acute Q-fever usually takes 10 to 40 days following exposure and typically begins with sudden high fever and flulike symptoms. Rarely, a few individuals develop a chronic illness with liver or heart complications, which is frequently fatal.

Background and Military Applications

Research on the military use of *C. burnetii* began in Russia before World War II. According to Ken Alibek (Kanatjan Alibekov), a former senior scientist in the Soviet biowarfare program, an outbreak of Q-fever among German soldiers in Crimea in 1943 may have resulted from intentional dissemination of the agent by the Russians. The United States Army studied experimental *C. burnetii* infections in soldiers, using vaccines, antibiotic treatment, and prophylaxis protocols in the mid-1950s and 1960s.

The exceptional infectivity of *C. burnetii* aerosols was observed in volunteers in open-air tests at Dugway Proving Ground, Utah. Inhalation of a single organism could cause infection in a susceptible person 40 days after exposure. A single dose of an inactivated whole-cell *C. burnetii* vaccine provided greater than 90 percent protection for 5 years against aerosol exposure.

C. burnetii is potentially dangerous as a weapon because it can be stored and disseminated as an aerosol or dry powder over a wide range of temperatures (–52° to +40°C, –60° to +104°F). Generally, the organism is hardy and survives in the environment in a spore form that allows significant spread of the agent by wind. Although culture is difficult and dangerous for laboratory workers, the organism can be grown to very high densities in live chick embryos. The organism can be transmitted by ticks, and it infects many animals that are usually asymptomatic carriers of the disease. A World Health Organization committee estimated in 1970 that if 50 kilograms (110 pounds) of a virulent *C. burnetii* strain were released upwind of a city of 500,000, it could incapacitate 125,000 people and kill 150.

Biological weapons stockpiles, including Q-fever bacteria, were destroyed by the United States upon signing the Biological and Toxin Weapons Convention of 1972, when other countries also agreed to end state-sponsored offensive biowarfare programs. The Soviet Union, however, continued biological weapons development into the early 1990s, including work with the Q-fever agent. As of 2003, it was not known if other countries were still producing the Q-fever agent as a biological weapon, but the Japanese religious cult Aum Shinrikyo attempted to weaponize the agent in the 1990s. Several cult members were reported to have been infected by the agent as they worked on it. In the United States, Q-fever was made a notifiable disease to public health authorities in 1999 because of increasing concerns of bioterrorism.

Q-fever (named after "query" fever when the cause of the unknown disease was first being investigated) was first described as a blood-transmissible disease in Queensland in 1937 by Edward H. Derrick, who was investigating a cluster of febrile illnesses of unknown origin among Australian abattoir workers. At about the same time, researchers in the Rocky Mountain Laboratory in Montana were studying a febrile illness transmitted by ticks. The causative agent, *Coxiella* (formerly *Rickettsia*) *burnetii,* was named for both MacFarlane Burnet (Melbourne, Australia) and Herald R. Cox (United States Public Health Service), who isolated and characterized the new pathogen in the late 1930s. Q-fever is colloquially known in different parts of the world as nine mile fever, north Queensland fever, and Balkan grippe.

Q-fever occurs on five continents, but the true incidence of Q-fever infection worldwide is unknown because a disease presenting as fever of unknown origin is hard to diagnose, many cases are mild or asymptomatic, and reporting is not required in many countries. It has infected military troops of all nations who have camped in endemic areas or near infected livestock, particularly goats and cattle. In Australia, about 500 cases of Q-fever occur annually in the meat processing industry, with younger workers and new recruits frequently being affected. In Europe, seroprevalence (evidence of exposure by testing blood) studies indicate that between 5 and 30 percent of the general population have antibodies to *C. burnetii.* A higher incidence is seen in rural areas with, occasional pet-associated outbreaks of human Q-fever in urban areas. About one-half of all people infected with *C. burnetii* have no sign or symptoms of clinical illness.

Medical Aspects

C. burnetii is a very small, gram-negative (does not absorb gram's stain) organism classified in the rickettsial family of bacteria, a group that includes the Rocky Mountain spotted fever and typhus agents. Rickettsia are often propagated in fertilized chicken eggs in the laboratory and require an intracellular environment in animal and arthropod hosts to grow and reproduce. Remarkably, *C. burnetii* lives and multiplies inside host cells, an environment that destroys most life forms. The organism has two distinct antigenic phases in animals and humans and in which antibodies are produced. Using serum antibody determinations one can determine the nature of the disease. Phase I antigens, for example, are indicative of chronic infection, while the presence of Phase II antigens usually shows acute onset of disease.

A dormant sporelike form of *C. burnetii* exists and is excreted in milk, urine, feces, and especially in the birth products (amniotic fluid and placental tissues) of infected animals. The spore is extremely hardy and can survive for long periods (weeks or months) in the surroundings of infected animals. Inhalation of the spore in contaminated dust up to one-half mile from the source may cause infection. The spore is not readily killed by sunlight, drying, or many common disinfectants. Sodium hypochlorite, formalin, ethanol, glutaraldehyde, gaseous formaldehyde and gamma irradiation can destroy *C. burnetii.* The ability to destroy the spore stage of *C. burnetii* is the current standard for adequate pasteurization of milk: 145° F (63° C) for at least 30 minutes, or 161° F (72° C) for 15 seconds.

C. burnetii is carried by a variety of birds, ticks, and mammals, including wild goats, cattle, sheep, kangaroos, wallabies and bandicoots, and other domestic and wild animals. Although it can cause abortion and stillbirth in goats and sheep, most animals infected with *C. burnetii* are healthy (asymptomatic). The organism may be transmitted by aerosols from animal excretions, contaminated straw, wool, hides, and clothing; ingestion or inhalation of raw milk or goat cheese; blood transfusions; and tick bites. Ticks are an important vector for maintenance of *C. burnetii* in the wild. Q-fever is an occupational hazard of persons working with animals or animal products and of laboratory workers who work with *C. burnetii.* Because the organism accumulates to high levels in birth products, people who assist at the birth of farm animals (such as animal husbandry workers and veterinarians) are at extremely high risk of infection. Other people at high risk are sheep, dairy, and meat processor (abattoir) workers, livestock farmers, and visitors to high-risk environments. Person-to-person spread is rare, but bone marrow- and blood transfusion-related transmission has occurred.

Q-fever has both acute and chronic disease forms. Acute Q-fever has a wide range of clinical symptoms, with no characteristic clinical picture. When symptomatic, the onset of Q-fever is usually 10 to 40 days after exposure, depending on the infecting dose. Early acute Q-fever is often characterized by a sudden onset of high fever (up to 105° F), with or without a flulike illness, pneumonia, or hepatitis. The most common symptoms are high fever, chills, sweating, severe headache, and malaise. Patients also frequently complain of muscle pain, fatigue, anorexia, weight loss, chest pain, and cough.

The disease normally resolves on its own without medical intervention, lasting up to 3 weeks, although recovery may be delayed in persons with hepatitis and pneumonia. Up to 15 percent of patients develop a post-Q-fever chronic fatigue syndrome that may last many months. Most people will recover within 60 days, even without treatment. However, prompt antibiotic treatment with a tetracycline can be helpful (see below). The antibiotic chloramphenical may be used in young children. Only 1 to 2 percent of people with acute Q-fever die of the disease. In general, recovery confers lifelong immunity against reinfection.

Attempted antibiotic prophylaxis of fever with tetracyclines has produced mixed results. Initiation of the antibiotics early in the incubation period (24 hours after exposure) prolonged the incubation period, but initiation of therapy late in the incubation period prevented disease development. Although the disease usually resolves without treatment, initiation of antibiotic treatment within the first few days of clinical illness shortens the course of the disease and can prevent progression to a chronic disease form.

Chronic Q-fever is uncommon, but it may result from *C. burnetii* infection that persists for more than 6 months, or it may develop from 1 to 20 years after initial infection. Rarely, chronic *C. burnetii* infection of the liver can lead to cirrhosis (chronic liver disease). The most serious complication, endocarditis (an inflammation of the heart valves), is difficult to diagnose. About 75 percent of such patients are male, over 40 years old, and have preexisting valvular heart disease or other risk factors (prosthetic heart valves, previous transplants, cancer, and chronic kidney disease). Chronic Q-fever is difficult to treat and is fatal in as many as 65 percent of cases.

Q-fever is difficult to diagnose without appropriate laboratory testing. A major clue to suspecting acute Q-fever infection is a history of contact with farm animals, animal by-products, birthing animals and their newborns, or tick bites. The diagnosis is proven by clinical suspicion and serology. Specific antibodies to the two antigenic phases of *C. burnetii* (phase I and phase II) can be measured in a blood sample taken at the onset of disease and during recovery by a variety of serological tests, including complement fixation testing (CFT), immunofluorescent antibody (IFA) testing, and enzyme-linked immunosorbent assay (ELISA). The indirect IFA is the most widely used method. *C. burnetii* may also be identified in infected tissues by using immunohistochemical (testing blood for exposure) methods and DNA detection methods such as the polymerase chain reaction test, or PCR, that can take very small amounts of genetic material from an assay, multiply them, and record the material's unique characteristics. Although it is possible to grow *C. burnetii* in fertilized chicken eggs, culture is difficult and dangerous for laboratory workers. Most infections are asymptomatic, or present as a flulike illness with no diagnosis. Atypical pneumonia is the most common diagnosis made.

Q-fever is a vaccine-preventable disease, but vaccination during the incubation period does not prevent the disease. Tetracyclines, as mentioned above, are the best prophylaxis for those exposed. A formalin-fixed (live cells killed with formaldehyde) whole-cell vaccine for Q-fever is commercially available in Canada and Australia and has protected humans in high-risk occupational settings. Individuals who have previously been exposed to *C. burnetii* should not receive the vaccine, because severe local skin reactions, including necrosis, can occur at the site of the injection. Persons wishing to be vaccinated must therefore first be screened for immune status with a skin reaction and complement fixation test (CFT). Protection depends primarily on cell-mediated immunity (response by lymphocytes). In the late 1970s, a nonhuman primate model was established to test experimental Q-fever vaccines at Fort Detrick. Vaccines for use in humans and animals are not commercially available in the United States. A Q-fever investigational new drug vaccine can be obtained from the United States Army Medical Research Institute of Infectious Diseases (USAMRIID) in Frederick, Maryland.

—*Amy E. Krafft*

See also: Agroterrorism (Agricultural Biological Warfare); Biological Warfare

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QL

QL is the code used by United States and the North Atlantic Treaty Organization (NATO) for the immediate precursor to VX nerve agent. It possesses a chemical structure that is still far removed from VX. As such, QL is a relatively nontoxic compound that, following a reaction with sulfur, isomerizes (changes the structure but not the essential elemental make-up) into a toxic VX molecule.

QL served as the basic component in the former U.S. chemical weapons stockpile, especially in the binary VX Bigeye glide bomb. Developed as part of a U.S. Navy program, the Bigeye munition used liquid QL and powdered elemental sulfur that would combine in a chemical reaction as the bomb flew over the target, releasing VX nerve agent. QL was also a key chemical component in the manufacturing process of the U.S. chemical weapons stockpile. QL was first produced in large batches. The product was then heated to accelerate the rearrangement of the molecule to form VX nerve agent.

The United States is currently destroying its chemical weapons stockpile, including remnants of QL that it produced during the Cold War. It is unknown whether foreign countries possess QL in any militarized quantities, or if they possess binary weapons utilizing this VX precursor.

—Eric A. Croddy

See also: Bigeye (BLU-80); Binary Chemical Munitions; Precursors; V-Agents

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R

RICIN

Ricin is a potentially lethal proteinaceous toxin found in the seeds of the castor bean plant, *Ricinus communis.* Upon entering the body, the toxin is strongly cytotoxic, killing most cells that it contacts by rapidly and irreversibly inhibiting protein synthesis. Entry into the body can be via injection, ingestion, or inhalation, with the lethal dose for the average person varying by route of entry.

The toxin's effects also vary depending on the route of entry. Based on a historical case study, injection of a lethal dose causes generalized weakness, fever, vomiting, dysphonia (difficulty speaking), and lymphadenopathy (swelling of lymph nodes) proximal to the site of injection within 24 hours, followed by symptoms of shock over the next 1–2 days and ultimately ending in circulatory collapse, diffuse hemorrhaging, and death on day three.

Following ingestion, symptoms of abdominal pain, vomiting, and (at times bloody) diarrhea appear within a few hours. Severe dehydration ensues over the next several days, leading to decreased urine output and blood pressure. If a lethal dose is consumed, death results in 3–5 days due to massive gastrointestinal hemorrhaging. If the patient survives past this time, however, he or she usually recovers.

Inhalation of a lethal dose leads to symptoms of cough, chest tightness, dyspnea (difficulty breathing), nausea, and myalgia (muscle aches) within approximately 3 hours. As the dyspnea worsens due to severe inflammation of the lungs and airways, cyanosis (bluish skin tone due to oxygen deprivation) rapidly develops. Death occurs 36 to 48 hours after initial exposure, as a result of either respiratory failure or circulatory collapse (stop of blood flow).

A high index of suspicion on the part of the health care practitioner and laboratory worker is required to identify ricin intoxication. Diagnostic confirmation is acquired via enzyme-linked immunosorbent assay (ELISA), a very specific test that uses enzyme reaction. Although a formalin-treated toxoid (toxin made harmless by treating with formaldehyde) with a proven safety record in animal studies has been submitted to the FDA for approval as an investigational new drug, treatment currently remains limited to supportive care. Promising research on the development of a newer toxoid incorporating only a small component of the toxin is ongoing. No antitoxin has been developed.

Ricin is listed in Schedule 1 of the Chemical Weapons Convention (CWC), meaning it is a toxic chemical banned by international law. It also falls under the purview of the Biological and Toxin Weapons Convention (BWC).

Ricin as a Biological Weapon

In addition to its high lethality, ricin is relatively inexpensive and easy to acquire and produce, and it is therefore considered by many analysts to be the present-day biological weapon of choice for actors with limited funds or technical expertise. Castor beans, though no longer grown in the United States, are widely available on the international market. The subsequent extraction of ricin is relatively straightforward and poses little danger to the handler. Approximately 1 million tons of castor beans are processed for the production of castor oil each year, yielding a waste product that is 5 percent ricin by weight.

The ease of acquisition and production of ricin is offset by the fact that it is easily affected by environmental factors as well as physical stress, making it very difficult to deliver as an aerosol. Thus, ricin is generally considered an excellent assassination weapon—especially given that it is tasteless, odorless, and very difficult to detect both pre- and postmortem—and a potentially dangerous food or

North London police raided a mosque in January 2003. Seven people were arrested under suspicion of manufacturing ricin toxin. (Reuters/Corbis)

water contaminant, but not a large-scale airborne threat. It also might be effectively delivered as part of a fragmentary device (a weapon that breaks up into smaller projectiles to create wider coverage) by coating explosive shrapnel with it.

Military History

The potential of ricin as a weapon of war has been evaluated since the beginning of the twentieth century. In early animal experiments performed by the U.S. Army, the results of which were first published in the *Journal of the American Medical Association* in 1903, bullets laced with the toxin were used to inflict poisoned wounds with firearms. Ricin was further investigated by the U.S. Army's Chemical Warfare Service (CWS) late in World War I, but the toxin was never deployed.

During World War II, the United States, along with Canada and Great Britain, again looked at ricin as a potential biological warfare (BW) agent. Called Agent W in the Allied arsenal, ricin was thoroughly explored by scientists at Edgewood Arsenal, and by the end of the war more than 1,700 kilograms of the toxin had been produced (Great Britain also conducted pilot-plant development of ricin). The toxin was processed into a liquid suspension and then incorporated into high-explosive shells and bombs, as well as into cluster bombs and plastic containers specially designed for its dispersal. Dubbed the W bomb, each cluster bomb was comprised of 500 pounds of independent 4-pound bomblets.

Field testing suggested that under appropriate weather conditions, the contents of just one W bomb distributed over 80 percent of a 100 x 100-yard target area would kill more than half of the area's population. Extrapolating this calculation, a 1-square-mile target required approximately 90 tons of weaponry, far less than the 600 tons required for phosgene bombs (the representative respiratory-effect chemical agent at the time), and thus it was deemed that the "W bomb" was worth pursuing. Ricin's lack of odor also suggested that its detection would be difficult, and its low persistency made it unlikely to hinder Allied advances after its delivery. It has been reported that the Allies did, in fact, consider using ricin against Japan, but the agent was never deployed in either the European or Pacific theater during World War II.

Human experimentation with ricin was performed within the confines of Japan's BW program during World War II, albeit indirectly: castor beans were placed in food that was then provided to prisoners of war over 2-week periods. Whether killed by the toxin or systematically executed to maintain secrecy about the tests, these test subjects invariably died as a result of their involvement in the experiments. Soviet researchers have performed similar experiments since World War II. Varied amounts of ricin and other poisons were added to the food of unsuspecting prisoners at Laboratory no. 1, a covert KGB facility. If the amount given did not prove lethal, more was injected with a syringe until death occurred.

In September 1978, Bulgarian dissident Georgy Markov was assassinated with ricin. While Markov awaited a bus on Waterloo Bridge in London, a Bulgarian secret service agent covertly fired a steel pellet filled with the toxin through the tip of a pneumatic umbrella into Markov's leg. Markov died 3 days later. A second Bulgarian, Vladimir Kostov, was targeted with a similar device in Paris but survived. Both the toxin and the umbrella designs used against Markov and Kostov were Soviet-made and had been provided for the operation by the KGB.

Following the 1991 Persian Gulf War, it was learned that Iraq had considered ricin as a potential BW agent in 1989 and had produced approximately 10 liters of concentrated ricin solution. All of this was used in field tests of 122-millimeter artillery shells, according to Iraqi declarations to the United Nations Special Committee (UNSCOM). Syria also is believed to have produced an unknown quantity of the toxin. In the early 1990s, Iran allegedly procured 120 tons of castor beans, possibly with the production of ricin in mind.

Ricin and Terrorism

In March 1991, four members of the American antigovernment group the Minnesota Patriots Council purchased castor beans through the mail after reading an advertisement in the right-wing *CBA Bulletin:* "Silent Tool of Justice . . . Castor Beans . . . Silent Death . . . Including instructions for extracting the deadly poison 'Ricin' from castor beans." Upon receiving the beans, these men extracted 0.7 grams of 5 percent ricin despite a lack of education and expertise. They plotted to kill law enforcement officials with the toxin but were discovered. In 1994 and 1995, they became the first persons to be convicted under the U.S. Biological Weapons Anti-Terrorism Act of 1989.

The extraction process for ricin for assassination purposes is described in the al-Qaeda training manual, and the Kurdish group Ansar al-Islam, which has known ties to al-Qaeda, has reportedly tested the toxin on animals and possibly even a man in northern Iraq. During the post-September 11 U.S. military action, instructions for the preparation of ricin were discovered in the basement of two Arab doctors connected to al-Qaeda, and trace amounts of ricin were detected at 5 or 6 of the approximately 110 sites searched throughout Afghanistan. But the quantity was too small to make any definitive assessment that ricin had been produced in the area.

In January 2003, the search by authorities of a London apartment uncovered castor beans and equipment for the extraction of ricin, leading to multiple arrests. Subsequent forensic analysis identified traces of ricin itself. Allegedly, four of the men arrested in the sweep—one of whom had been in contact with persons employed on a British military base—were linked to al-Qaeda.

In March 2003, two vials of ricin were discovered in a locker at the Gare de Lyon railway station in Paris. To date, no arrests have been made in the case.

Ricin and Crime

Ricin has been the agent of choice in numerous criminal plots over the past two decades.

In 1982, for example, Texas attorney William A. Chanslor was arrested for attempting to acquire ricin, which he claimed had been sought so that he could assist his wife in committing suicide. He was found guilty of conspiracy to commit murder, but the conviction was overturned on appeal. Before he could be retried, Chanslor pled guilty and was sentenced to probation.

In 1985, Montgomery Todd Meeks was convicted of the attempted murder of his father. Meeks purchased what was apparently a vial of ricin toxin itself and poured the contents of the vial into his father's water glass (and water pitcher). Before the tainted water could be consumed, however, Meeks's father was alerted to the plot by the county sheriff's office.

A decade later, cardiologist Michael Farrar discovered a supply of castor beans in the purse of his estranged wife, Debora Green. Farrar had been suffering from unusual symptoms that had left him hospitalized on three separate occasions earlier that year, and it was soon determined that ricin had in fact been the cause of his illness in each instance. Less than a month later, Green set fire to her own home, killing two of her children. She was arrested and in April 1996 pleaded no contest to charges of murder and attempted murder.

In 1997, authorities responding to an emergency call entered the residence of one Thomas C. Leahy, who after a night of drinking had shot his son in the face. Investigation of the crime scene revealed approximately 0.7 grams of 4 percent ricin in his home. Leahy's wife later testified that Thomas Leahy had planned to poison his mother and former wife with the toxin. He was ultimately sentenced to 6 and one-half years in prison.

Medical Applications

Given its cytotoxic (cell-killing) effect, ricin has been pursued as a potential therapy for cancer for the past half-century. To be used to inhibit tumor growth, however, the toxin must be delivered in such a way that it targets cancerous cells without affecting normal cells. In recent years, scientists have accomplished this feat by conjugating the active component of ricin with tumor-specific monoclonal (very specific and uniform) antibodies to create "immunotoxins" capable of selective cell destruction. Preliminary studies with a number of different immunotoxins have shown significant promise.

—*Rich Pilch*

See also: Bioterrorism

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RIFT VALLEY FEVER

Rift Valley fever (RVF) is a viral disease transmitted to humans by contact with infected animals or through the bite of infected mosquitoes. In a majority of cases, RVF is transmitted by contamination of broken skin during animal handling or by inhalation of infected fluids (aerosols). This can occur during the slaughter of infected livestock. Infection of health workers may occur during careless handling of patients' blood or other body fluids. Proven to be highly infectious under natural circumstances as an aerosol, RVF is an excellent candidate for deliberate dissemination in biowarfare. In mild cases, RVF symptoms are similar to the common flu with chills, fever, and muscle aches, but in 1 to 2 percent of cases, complications of eye inflammation, brain infection (encephalitis) or liver damage, and abnormal bleeding (hemorrhagic fever) can be serious or fatal. Domestic sheep, cattle, camels, and goats are susceptible to RVF; abortion among pregnant animals is a common outcome. Sheep are particularly vulnerable; in fact, the virus was originally isolated from a newborn lamb in 1930.

RVF was discovered in eastern Africa as a disease of sheep and other domestic livestock. Mosquitoes of many species are the source for natural disease transmission among animals. Infected eggs of female mosquitoes also can carry RVF through successive insect generations. In central Africa, an increase in mosquito populations after heavy rains or flooding often precedes livestock outbreaks, and a sudden increase of abortions or deaths of newborn lambs may presage human outbreaks. In 1977, an epidemic of RVF in Egypt heralded the spread of RVF to livestock in relatively dry regions of north Africa, where channels of irrigation water or flooded fields offer hospitality to mosquitoes. In 2000, RVF caused local epidemics for the first time outside of the African continent (in Saudi Arabia and Yemen). Thus, the virus has adapted to new environments.

Technical Details

The virus of RVF is midsize (0.1 micron in diameter) and belongs to the family of bunyaviruses, genus *Phlebovirus.* It is consists of protein-coated helical RNA enclosed within a fatty envelope that aids virus entry by targeting receptors on the host cell. In the first round of virus multiplication, RNA fragments provided by the host cell enable expression—that is, the initial blueprint—of the virus's genetic information. Eventually, the virus becomes self-replicating and produces the proteins needed for the maturation and release of infectious particles.

Initially, the virus multiplies in white blood cells at the site of a mosquito bite. After a latent period of 2–6 days, it spreads through the bloodstream to multiply into other tissues and organs. A symptomatic phase then lasts 4–7 days. On days two or three after infection, a heavy load of virus is released into the bloodstream (viremia). This is an optimal interval for isolation of the virus by infecting mice with blood from the patient or by using tissue cultures, or for detection by newer molecular methods of polymerase chain reaction (PCR). Prior to the existence of PCR, diagnosis usually depended upon detection of protective antibodies that increase for 1–2 weeks after infection. Signs of liver damage and bleeding from the gums, under the skin, or into the intestinal tract can be seen at 2–4 days after infection. Up to 50 percent of patients with these "hemorrhagic fever" complications may die. Complications of encephalitis or eye disease may be delayed for 1–4 weeks after the onset of fever but are rarely fatal. The overall death rate of RVF is about 1 percent.

In sheep, vaccination with a live attenuated strain of RVF can produce long-lasting immunity, but vaccination of cattle depends upon a killed virus that is less effective and requires regular follow-ups to ensure immunity. Human vaccination is not yet feasible. Control of mosquito populations is the basic public health measure to limit RVF spread. Treatment of human RVF addresses the symptoms only; however, in severe cases, the antiviral drug ribavirin, administered intravenously, may be life-saving.

RFV has been tested for use in biowarfare by the U.S. Army. The results of these tests are classified. This agent was not reported to be a major consideration in the Soviet bioweapons program; however, a potential for criminal abuse exists. Military or civilian populations exposed to RVF aerosols could be out of action for several days.

—Phil Grimley

See also: Crimean-Congo Hemorrhagic Fever; Hemorrhagic Fevers; Marburg Virus

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RIOT CONTROL AGENTS

A riot control agent (RCA) is any nonlethal, nonpersistent substance used to disperse a crowd and move its members in a specific direction, normally away from a key area. Riot control agents have a long history of use by law enforcement agencies to break up mobs, protests, looting, or other activities without using lethal force.

In 1912, Parisian police used "hand bombs" filled with ethyl bromacetate, an early lacrimator or tearing agent, against rioters and looters. French soldiers used this same agent against German soldiers in World War I, and more irritating substances were also synthesized for use on the battlefield. Following World War I, the continued development of RCAs as war gases waned with the development of more toxic chemicals. Although the United States used RCAs to clear tunnels in Vietnam (mostly CS agent), the use of RCAs by the U.S. military today is generally limited to confidence training with protective masks and to law enforcement functions such as riot control, internment and resettlement operations, and military corrections. Today, police worldwide use RCAs for law enforcement, corrections, and crowd control activities.

Agents used for riot control should meet two criteria: (1) they must be able to irritate and disable their human targets, and (2) they must inflict only temporary effects that will not require medical treatment. Traditional RCAs include the World War I-era chemical CN, or chloroacetophenon (also known commercially as Mace), which was commercially developed in the 1920s by the British and used in the United States to protect banks and armored cars from robbery in the 1930s. The British also used CN in post-WWII civil disturbances in Cyprus, and the United States used this agent against rioters and criminals in the 1960s and 1970s. CS gas has replaced CN in most police and military uses. The advantage of CS agent (delivered as a powder or in a thermal fog) is that it is much more intense in causing pain to the eyes, nose, and throat, while being less toxic than CN.

Water, either dispersed with a high-pressure hose or a water cannon, can also be used as an RCA and is especially effective in cold weather. Water was used against civil rights activists in the United States in the 1960s and is being used today in countries such as Indonesia, South Africa, and Israel. Government officials in the United States, however, normally avoid using firefighting equipment in riot control, in order to maintain these units' reputation for community assistance.

Technical Details

The most common RCAs used today are CS gas and oleoresin capsicum (OC or "pepper spray"). CS, named after its manufacturer, Corson and Stoughton, which developed the chemical in 1928, is shorthand for the chemical name O-chlorobenzylidine malononitrile. It emits a pepperlike odor and causes burning and tearing in the eyes, shortness of breath, tightness in the chest, coughing, wheezing, and stinging of exposed skin. When a person is exposed to CS in effective quantities, he or she loses the ability to communicate with others or coordinate his or her actions. The effects of CS typically wear off after 5–10 minutes in fresh air. During the siege of the Branch Davidian compound at Waco, Texas, in 1993, large quantities of CS agent mixed in solvent were used in an attempt to resolve a standoff. Unfortunately, the use of CS in this instance probably helped create an uncontrollable fire that left 80 people dead.

The naturally occurring substance oleoresin capsicum (OC or "pepper spray") is extracted from various types of pepper plants and is used widely by the United States military and police. OC was introduced to United States law enforcement agents and mail carriers in aerosol form to repel animals and humans in 1973, and its usage spread during the 1980s. By dint of its "natural origin," OC is generally considered a safer alternative to other RCAs. Some law enforcement personnel consider its overall effectiveness in crowd control, however, to be weak when compared to other RCAs such as CS agent. It creates sensations of burning in the eyes, involuntary closing of the eyelids, coughing, gagging, loss of breath, a burning sensation on exposed skin, and loss of strength and coordination. Like CS, OC will incapacitate a targeted person, leaving him or her unable to coordinate actions. The effects of OC typically wear off after 30–40 minutes in fresh air.

A third riot control agent, used less often today, is CR, known chemically as dibenz-(b,f)-1,4-oxazepine or dibenzoxazepine. CR was synthesized in 1962 and approved for use by the U.S. Army in 1974. CR is more irritating than CS and also more persistent. CR liquid can be dispersed from a portable dispensing device that can be carried on the back by a law enforcement officer. Although some studies suggest that CR is even more effective and less toxic than CS tear agent, there is a paucity of human data with regard to the use of CR, and thus it has not found widespread application as an RCA.

The impact of RCAs is measured as a function of concentration and time, also known as the Haber Product. One such measure of severity is the intolerable concentration, or IC_{50}. The IC_{50} is the concentration of an irritating substance, such a tear gas, that 50 percent of a given population (human or animal) find intolerable after one minute. CS, for example, has an IC_{50} of 3.6 milligrams per minute per meters cubed (in aerosol form).

Some experiments for determining IC_{50} have been designed using human test subjects, including those conducted by the United Kingdom. In one trial, volunteers were brought into a room and told that a 5-pound Sterling bank note was hidden inside. As the subjects looked for the phantom bill, CS agent was poured into the room. The amount of time it took before subjects gave up the fruitless search due to intense discomfort caused by the RCA was used to calculate the overall effectiveness of CS agent in humans.

The concentration of CS that would cause death to 50 percent of the population is represented by LCt_{50}, where L stands for lethal, C is concentration and t is the exposure time. Although RCAs are intended to be nonlethal, they can cause serious side effects, including bronchitis, asthma, lung damage, eye damage, and skin inflammation. Death may occur from large exposures to CS in older populations, children, and those with respiratory conditions. First aid for RCAs includes moving to uncontaminated areas; allowing powdered agents to blow off of clothing and skin; not touching one's eyes, mouth, or other mucous membranes; and showering.

Operational Aspects

Riot control agents can be dispersed by pyrotechnics, canister burst, aerosol, fogging, and grenades. The effective use of a riot control agent depends on the area and the weather. An agent is normally released 15 to 100 meters from the target, depending on wind speed. As wind speed increases, the distance to the target needs to be shortened to be effective. The employing force should only use RCAs when the target population has an escape route, as panic and additional injuries could result from a trapped crowd. As an alternative, high-pressure water can be used in confined areas (e.g., alleys) or narrow fronts (e.g., a roadblock). Those who employ RCAs will usually need personal protection via protective masks, except when using high-pressure water or water cannons. The employing force needs to be prepared to further break up remaining groups, prevent illegal activities, and assist the injured or unconscious. Riot control agents, if unsuccessful at convincing people to move away from the area, have the potential to incense an already motivated crowd to inflict more violence or property damage.

Currently, the use of RCAs by the United States is limited by two documents, one international and one domestic. The 1993 Chemical Weapons Convention (CWC) bans the use of riot control agents as a method of warfare. Riot control agents, defined as "any chemical . . . which can produce rapidly in humans sensory irritation or disabling physical effects which disappear within a short time following termination of exposure" (CWC, Article II, Sec. 7) are not prohibited, however, when used for law enforcement, including domestic riot control purposes.

The United States has further limited its use of riot control agents by Executive Order 11850, signed by President Gerald Ford in 1975. In this order, the United States renounced first use of riot control agents in war except in defensive military modes to save lives. The order specified four classes of events where riot control agents can be used with prior presidential approval: (1) in a riot control situation in an area under U.S. military control (e.g., to prevent riots at an enemy prisoner of war camp); (2) when civilians are being used to "mask or screen attacks and civilian casualties can be reduced or avoided"; (3) rescue missions; and (4) in rear echelons to "protect convoys from civil disturbances, terrorists and paramilitary organizations" (Executive Order 11850). Much of the rationale for the United States to maintain the exception for the possible use of RCAs in warfare goes back to the Vietnam War, when U.S. forces used CS tear agent to suppress enemy fire in order to undertake search and rescue missions for missing pilots and air crews.

Employment of RCAs should be guided by a priority of force. The United States military, for example, suggests the use of chemical irritants only after verbal persuasion and show of force, but before the use of physical force, presentation of deadly force, or use of deadly force. In most cases, law enforcement officials weigh the benefits of using nonlethal tactics such as riot control agents against possible injuries and further inflaming the crowd.

—Eugenia K. Guilmartin

See also: Chemical Weapons Convention (CWC); CS

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ROCKY MOUNTAIN SPOTTED FEVER

Rocky Mountain spotted fever (RMSF) is a potentially severe, arthropod-borne rickettsial infection endemic to most of North America and parts of South America. The disease is caused by the bacterium *Rickettsia rickettsii* and is spread to humans by the bites of ixodid (hard-bodied type) ticks. Early infection is difficult to diagnose because of nonspecific symptoms (fever, headache, muscle and joint pain). The lack of a prompt diagnosis and the resulting delay in treatment can greatly increase the severity of the disease.

The first description of RMSF appeared following a case in south-central Idaho, in the Snake River Valley in the late 1800s. The appearance of a characteristic rash first led to the disease to be described as black measles. The name Rocky Mountain spotted fever later supplanted this early terminology, due to the geographic distribution of infections that first came to the attention of medical care providers. The leading medical researcher in the field was Howard T. Ricketts, after whom this entire class of organisms was named. He and his colleagues not only identified the infective agent of RMSF, but they also described in detail the role of the tick vector and the life cycle of the organism.

The natural hosts of *R. rickettsii* include the common dog tick (*Dermacentor variabilis*) in the eastern United States and the Rocky Mountain wood tick (*D. andersoni*) in the intermountain west and Pacific coast. The microorganisms propagate within a host and can be transmitted to humans in saliva released from a feeding tick. Ticks may feed for hours on a host, and long feeding periods are necessary to transmit *R. rickettsii* bacteria. General symptoms (fever, headache, nausea, and muscle pain) can appear 7–10 days after exposure. A rash can begin 3–5 days after the onset of symptoms and may develop into a characteristic pattern of dark red spots that occur on the extremities (arms, legs, ankles), including the palms of the hands and soles of the feet in most infected individuals.

Among other microbial pathogens, RMSF has been studied by U.S. scientists as an offensive weapon. Between 1943 and 1969, five researchers at Fort Detrick, Maryland, became infected with RMSF while conducting research on the pathogen.

The United States also conducted field aerosolization tests during the Cold War. RMSF can also be delivered as a biological agent, using infected ticks as the disease-carrying vector.

Rocky Mountain spotted fever is the most commonly reported rickettsial infection in the United States. Although prompt and efficacious antibiotic treatment has significantly reduced the mortality of infection, approximately 5 percent of individuals infected with *R. rickettsii* die from the disease. One set of data showed that when treated within 5 days of symptoms, most survived, while those who received antibiotics within 7 days died. Prior to the widespread use of antibiotics to treat the disease, a 30 percent case fatality was not uncommon. The U.S. Centers for Disease Control and Prevention report that children are at greatest risk for the disease, accounting for more than 60 percent of all cases reported in the United States. Antibiotics such as doxycycline and chloramphenicol are effective in treating RMSF. Left unchecked, RMSF causes damage to the tissues vital for proper circulation, leading to hemorrhage and sometimes formation of blood clots (thrombosis).

Rocky Mountain spotted fever is difficult to diagnose, and the consequences of delayed treatment are significant. Improved diagnostics are in development, as is a standard case definition to help physicians identify and report RMSF to state public health officials. There are no vaccines approved for human use for protection against RMSF.

—*J. Russ Forney*

See also: Biological Warfare; United States: Chemical and Biological Weapons Programs

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RUSSIA: CHEMICAL AND BIOLOGICAL WEAPONS PROGRAMS

Russia inherited the largest stockpile of chemical and biological agents in the world from the former Soviet Union (FSU). Even after signing the Chemical Weapons Convention (CWC) and the Biological and Toxin Weapons Convention (BTWC), Russia continued to develop chemical and biological weapons in secrecy. In 1992, President Boris Yeltsin claimed that the CBW programs in Russia had been abandoned and that Russia was committed to destroying its stockpiles of chemical and biological weapons and operating within the framework of the CWC and the BTWC. Some observers believe, however, that Russia still has an offensive CW and BW program today, despite promises to the international community that their research and development in this area are strictly for defensive purposes.

Russia also continues to have financial problems that directly affect the demilitarization and disposal of its current stockpiles. Whether the nation is fully committed to the elimination and nonproliferation of CBW or not, Russia's legacy as a chemical and biological superpower continues to have an effect on global security.

All aspects of Russian CBW programs must be safeguarded to prevent other groups and nations of concern from obtaining CBW capabilities, whether through theft, black market sales, or unauthorized technology transfer. Protecting the remaining stockpiles while awaiting demilitarization is a costly venture for Russia because it lacks the resources to keep its scientists employed. The United States, however, has worked with Russia through threat reduction initiatives to redirect their scientists and illicit programs toward legitimate research and development. CBW programs in Russia were quite extensive, and the breakup of the Soviet Union has made it difficult to maintain physical security for the materials and equipment associated with the programs. The dual nature of chemical and biological technology also makes it difficult to maintain the type of export controls needed to keep other nations from transferring legitimate chemical and biological research and development technology to clandestine operations.

Historical Background

Chemical and biological weapons use in Russia dates back to at least the sixteenth century, when Russian troops allegedly used plague-infested corpses against the Swedes. Until the end of World War II, however, Russia was more often the victim of CBW attacks. During World War I, the Germans—in a sabotage operation conducted in the United States and possibly elsewhere—infected with glanders and other diseases livestock bound for Russia, and Russia also suffered more than 60 percent of all the chemical-related casualties in that conflict. In 1919, during the Russian Civil War, the British used

Chemical weapons storage, Sartov region. Destruction of Soviet-era chemical weapons in Russia has been painfully slow. (Reuters/Corbis)

adamsite against the Bolsheviks. In 1939, the Japanese poisoned Soviet water supplies along the Mongolian border with intestinal typhoid bacteria.

Russia's history of foreign invasion and CBW attacks contributed to a feeling of distrust of others that led to an aggressive offensive CBW doctrine, even after the use of such weapons was determined to be inhumane by the international community. The Soviet-era CBW programs officially began with a 1967 decree by the Communist Party Central Committee and the U.S.S.R. Council of Ministers, which directed the preparations for chemical and biological war. The 1967 decree established the program that the West codenamed the F programs (Flute, Fouette, Fagot, Flask, Ferment, Factor, and Flora).

Russian CBW programs were an even more closely kept secret than their nuclear program; Soviet offensive CBW programs were well hidden behind legitimate bioscience and chemical industry covers. Most of what is known about their efforts comes from former Russian scientists like Ken Alibek, who immigrated to the United States after the end of the Cold War. He was the former Deputy Director of Biopreparat, the principal Soviet government agency responsible for biological weapons research and development (*see* Biopreparat).

Biological Weapons

The Soviet BW program involved thousands of personnel from the military, education, and civilian sectors. The Soviets compartmentalized sensitive aspects of the program so that very few people had knowledge of the program as a whole and its intended military applications. Although Russia produced tons of agents such as anthrax, smallpox, plague, tularemia, glanders, Venezuelan equine encephalitis, Q-fever, and Marburg, research was also conducted on many more types of agents and organisms.

In 1946, an army biological research facility was built at Sverdlovsk; Soviet scientists used data culled from germ warfare documents taken from the Japanese in Manchuria. In 1953, another bacteriological facility was built at Kirov. Both Sverdlovsk and Kirov suffered serious accidents. In 1953, a leak occurred at the Kirov facility in which anthrax was released into the city's sewer system. The West remained unaware of this incident, and when a rodent was found a few years later in the sewer system with a more virulent strain of anthrax, the Soviets were able to further their BW program using this new strain.

In 1979, there was an anthrax release at Sverdlovsk that apparently occurred when a technician forgot to replace a clogged filter that had been removed. The plant released a cloud of anthrax that allegedly killed hundreds of people. The Soviets were unable to keep this incident out of the public eye and, for the first time, the West had clear evidence that the Soviet Union was in violation of the BTWC. Moscow officials denied the incident and said that it was a naturally occurring outbreak of anthrax among domestic animals and that all the patients had been treated successfully. Eventually, however, Moscow admitted that 96 people had been infected and that 66 of those infected had died. The Soviets then launched a major cover-up to protect their BW program. Unfortunately, residents continued to get sick; anthrax spores can survive in a dormant state for years. The Sverdlovsk incident became known as the biological Chernobyl, and to this day, Moscow claims that the outbreak was due to contaminated meat.

Subsequent Western focus on the incident at Sverdlovsk meant that continued operations there would be difficult. Four facilities had originally been established under the Ministry of Defense; however, research and development (R&D) was carried out within institutions under the Ministry of Defense, Ministry of Agriculture, Ministry of Health, Academy of Sciences, and Biopreparat. Eventually, between forty and fifty different institutions were involved in some aspect of the BW program, an organizational network that led to the continued secrecy of the program. Not all were engaged in microbiology or weapons R&D. Some were cover operations to further secure the program. Others supported fermenter design and the construction of test chambers. Because of its geographic isolation, Vozrozhdeniye Island was used as a test site in the Aral Sea where open-air testing of BW agents took place.

Biopreparat took advantage of the pressure that was put on the Ministry of Defense and pushed to become the main developer of new biological weapons using agents such as tularemia. Because Biopreparat was a civilian organization, it was easier to conceal its activities from the West under the guise of medical research. The Ministry of Defense, the Military Industrial Commission, and other state organs, all the way up to the Central Committee and the Office of the President, ultimately controlled the programs undertaken by Biopreparat. Eventually, all biological weapons-making equipment and materials were transferred to Stepnogorsk, a Biopreparat-controlled research facility. The Ministry of Defense facilities continued research, but the small scale of this research meant that they were effectively in charge of storage.

The first mission of Stepnogorsk was to take the virulent strain of anthrax that had been discovered in Kirov in 1953, Anthrax 836, and develop a technique for reproducing it on a massive scale. Anthrax 836 was considered to be the most suitable for mass production because it could be transported without losing its virulence. Stepnogorsk created an assembly line for mass production of weaponized anthrax, a capability previously unavailable to the Soviet military.

The success of the BW program also led the Soviet Union to develop a coherent BW employment doctrine. Biological weapons were considered strategic or operational weapons, meaning that they were not meant for tactical operations on the battlefield. Strategic agents were to be targeted against the continental United States for use in all-out war, and operational agents were to be used against North Atlantic Treaty Organization staging and logistic areas in the event of war in Europe. Strategic agents were typically lethal and included smallpox, anthrax, and plague. Operational agents such as tularemia and glanders were intended to incapacitate soldiers and overwhelm medical services. The overall goal of Soviet doctrine was to create mass casualties and disrupt critical civilian and military infrastructures. The Soviets worked continuously to make this doctrine a reality by improving the effectiveness of biological agents through genetic engineering and improved delivery systems.

R&D and production were concealed within the legitimate biotechnology and pharmaceutical industries. Genetic engineering produced a new generation of BW agents. Chimeric agents were developed; this genetic alteration of infectious organisms caused victims to display symptoms of several infectious organisms. Chimeric agents also shortened the time between infection and the onset of symptoms and caused symptoms to reveal themselves at noncharacteristic times. What resulted were biological agents with increased virulence, improved resistance to antibiotics, longer shelf life, and more ease of dissemination. The new agents could survive environmental effects that greatly reduced the virulence of naturally occurring organisms.

Two biological agents within the Russian arsenal, smallpox and Marburg, were especially dangerous. The World Health Organization (WHO) announced in May of 1980 that smallpox had been eradicated from the planet. Ironically, by its membership in the United Nations and its large vaccine production capacity, Soviet science and medicine had played a large role in the worldwide eradication of natural incidence of smallpox. When the WHO named the Centers for Disease Control in Atlanta and the Ivanovsky Institute of Virology in Moscow as the only two sites where limited stockpiles of smallpox could be held for research purposes, however, Moscow saw this as an opportunity to exploit smallpox as a weapon. In the 1981–1985 Five-Year Plan, Moscow listed smallpox as a virus targeted for improvement for military purposes. The Soviet program worked to shorten the time it takes smallpox symptoms to occur and to strengthen its virulence so that any vaccine would be ineffective. This was quite different from the West's policy, which only sought to weaponize agents for which there was a cure. A strong and stable strain of Marburg was also produced by Soviet researchers. The Soviet Union and Russia continued on this path into the early 1990s.

Equally important to the Russian BW program was the development of effective mechanisms for delivery of biological agents. At the Institute of Ultra-Pure Biopreparations, one of the major projects was the modification of cruise missiles to deliver BW agents. Soviet SS-11 and SS-18 missiles were equipped with biological weapons to attack strategic targets within the United States.

Chemical Weapons

The Soviet Union produced thousands of tons of chemical weapons at multiple facilities. The Soviet arsenal included nerve (sarin, soman, and Russian VX) and blister agents (mustard and lewisite). Vil Mirzayanov, eventually a Russian émigré to the United States, had worked for more than 25 years in the Soviet chemical weapons program and helped develop a new series of extremely lethal third-generation nerve agents under the Foliant program. These were binary agents—ones that were nontoxic by themselves but became lethal when mixed together. He also worked to develop agents that were not detectable by Western early warning systems.

Beginning in the 1920s, the Military Chemical Complex (MCC) of the Soviet Union secretly developed, produced, and stockpiled chemical weapons. At a 1957 meeting of the Communist Party, Defense Minister Marshal Georgi K. Zhukov said that the U.S.S.R. would assume that future war would include nuclear, chemical, and biological weapons. The MCC went through a series of changes as the CW program evolved. Today, military chemical affairs are handled by the Radiation, Chemical, and Biological Protection Forces (RCB), which have their own research, academic, and testing organizations.

Under the Soviet system, chemicals were divided into three categories based on their combat effectiveness. First-generation chemical weapons were those World War I vintage agents, including persistent toxic chemicals that produce a skin-blistering or general toxic effect (mustard, for example), nonpersistent toxic chemicals (such as phosgene), and irritants (riot control agents) such as adamsite and CS gas. Second-generation chemical weapons were organophosphorus toxic chemicals that cause a paralytic nerve action, including tabun, sarin, soman, and Soviet V-gas. Sarin, soman, and Soviet V-gas were produced on a large scale to be included in the army arsenal. Third-generation chemical weapons encompassed new types of toxic chemicals and more effective means of delivery during combat. The Foliant program produced several of these agents, of which A-232 and novichok-5 became the most useful for combat operations. Not much is known about these third-generation chemical weapons.

Soviet CW testing was conducted near the Caspian Sea, near Lake Baikal, and even in cities close to Moscow. Some of the most prominent testing facilities were Kuzminki and Kuntsevo in Moscow, Shikhany Central Military Chemical Proving Grounds on the banks of the Volga River, and Nukus, located on the Ustyurt Plateau in Karakalpakia, Uzbekistan. Chemicals needed to be tested in different areas to demonstrate their battlefield effectiveness in various climate conditions.

Until the early 1980s, chemicals were even tested during training exercises and on humans, although it is not known if these tests were performed with the consent of the participants. The Soviet program has received much domestic criticism because of the legacy of reported environmental damage produced by CW testing, although the type and extent of this purported damage are still unclear.

Although chemical weapons production facilities were numerous, they were concentrated in the Volga basin. The experimental plant Volsk, for example, produced various toxic chemicals and their precursors, including irritants and incapacitants. The S. M. Kirov Chemical Plant in Stalingrad produced large-scale quantities of yperite and phosgene. V-gas and other toxic agents were produced near the city of Novocheboksarsk.

Under the U.S.-Soviet Wyoming Memorandum of 1989 in which the United States and the U.S.S.R. exchanged information on their military chemical facilities, the Soviet Union identified locations where chemical weapons were stored. Some of the storage sites include the Shikhany Central Military Chemical Proving Grounds, Gornyy, and Kambarka. Under the Chemical Weapons Convention, Russia made further declarations that included civilian entities; however, there are still questions as to whether full declarations and disclosures have been made by Russia.

Russia inherited an extensive chemical arsenal from the Soviet Union. First-generation weapons (e.g., lewisite and sulfur mustard) were deployable from 122-millimeter and 152-millimeter artillery shells, 100-kilogram aircraft bombs, and 500-kilogram and 1,500-kilogram aircraft spray rigs. Second-generation chemical weapons (e.g., sarin and soman) were deployable in 122-millimeter, 130-millimeter, and 152-millimeter nonrocket artillery shells; 122-millimeter, 140-millimeter, and 240-millimeter rocket artillery shells; 250-kilogram aircraft bombs; and 350-kilogram aircraft spray rigs. Third-generation chemical weapons (e.g., VX) were deployable in 130-millimeter and 122-millimeter nonrocket artillery shells and 540-millimeter and 884-millimeter nose sections of tactical missiles.

CBW Arms Control Efforts

Currently, Russia openly supports nonproliferation regimes and arms control treaties. Russia does, however, export missile and nuclear technology and dual-use biological and chemical technology to nations of concern (e.g., Iran and North Korea). Because of the dual-use nature of chemical and biological weapons technology, countries like Iran could divert imported equipment or expertise for clandestine purposes. Russia has sought to strengthen its export controls and physical security of stockpiles in recent years; unfortunately, the dual-use nature of these programs makes foolproof safeguards virtually impossible. Russia has worked closely with the United States and other parties to the CWC and BTWC to improve its nonproliferation controls.

The most effective method for securing the Russian CW and BW programs would be destruction of current stockpiles, conversion of former production facilities, and the provision of peaceful work for former weapons scientists so that they are not lured into illicit programs in nations of concern. Russia has run into several problems in achieving these goals. Destruction of current stockpiles, for example, imposes an economic burden on Russia that it can ill afford.

Although former Soviet republics such as the Ukraine, Kazakhstan, and Uzbekistan have abandoned and closed the BW facilities located within their territories, Russia has not taken such broad steps in the area of verifiable biological weapons destruction. The BTWC does not have requirements or provisions for verification to regulate the destruction process. The CWC, however, has the most stringent verification requirements of any arms control treaty and commits its parties to destroy their chemical weapons. In addition, the Bilateral Destruction Agreement between the United States and Russia sought to further eliminate the chemical stockpiles and chemical weapon production facilities.

The legal and organizational framework for chemical weapon destruction is the bill entitled "On the Destruction of Chemical Weapons," which was approved by the Russian Parliament and signed into law on May 2, 1997. This document establishes the basis for destruction, and Government Order no. 305 sets up the timeline and priority for chemical weapon destruction. Russia still argues, however, that legitimate chemical industries are tied to plants that manufactured CW agents and that destruction of these facilities would directly affect the legitimate business conducted within the Russian chemical industry. Russian officials also argue against complete destruction because chemical weapon production facilities can safely be converted to civilian industrial use. There need to be strict verification measures, however, to ensure that these facilities cannot be redirected to weapons production. U.S. officials are concerned that converted chemical weapons production facilities could still be mobilized for production in times of war and could continue to act as covers for clandestine operations.

The United States has cooperative programs with Russia to assist with the destruction process. In addition to cooperative threat reduction programs, Russia is also seeking to engage in joint ventures with Western chemical and pharmaceutical companies to generate revenue and to create transparency within their legitimate research, development, and production facilities. Unfortunately, financial hardship and political instability in Russia do not make it an attractive place for foreign investment.

Due to the financial and ecological burden of chemical weapon destruction, Russia has missed CWC deadlines for destruction of its most dangerous chemical weapons. It has requested extensions, but with a deadline of 2007 for destruction of all chemical weapons stockpiles, Russia will most likely not be able to destroy all of its chemical stockpiles in time. Russian officials have already stated that they will request a 5-year extension until 2012 to meet the goal of destroying all of the chemical weapons within the former Soviet Union.

—Stephanie Fitzpatrick

See also: Aralsk Smallpox Outbreak; Biopreparat; Shikhany; Sverdlovsk Anthrax Accident; Typhus (Rickettsia Prowazekii); World War I

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S

SABOTAGE

Sabotage is a word used to describe attacks against selected targets (usually one's own organization, employer, or military) to damage property or personnel. Sabotage can be conducted in a variety of forms, including the use of weapons of mass destruction in terrorism or war. In a military context, sabotage is a set of actions designed to harass, ruin, or otherwise interfere with the normal operations of the enemy. An agent already inside the targeted organization is often used to commit sabotage, or special operation forces are sent behind enemy lines in an attempt to cut communications, destroy logistical nodes, or set off explosions to degrade the enemy's ability to fight.

The origin of the word *sabotage* has been linked to French activists during the Industrial Revolution, who struck against modern industrial facilities. According to this version, workers put a wooden shoe (*sabot*) into the workings of a labor-saving machine, wrecking the device and preserving their jobs. This story is probably apocryphal, as *sabot* probably referred to a wooden pin that connected train tracks; when the pin was removed, the tracks would fail, setting the stage for a catastrophic train derailment.

In chemical and biological warfare, the primary routes of potential sabotage include the release of toxic industrial chemicals. The Bhopal, India, tragedy in the early 1980s is considered by many to be the worst case of industrial sabotage ever committed by a disgruntled employee (*see* Bhopal India: Union Carbide Accident). Sabotage can also take the form of deliberate contamination of food or beverages with pathogens, toxins, or highly poisonous chemical compounds. Militaries and terrorist organizations could both use chemical or biological sabotage as a part of, or prelude to, organized campaigns. Sabotage need not be directly targeted against people but perhaps could also target the economic well-being of a particular industry. The release of an animal or plant disease could be part of sabotage operations, causing considerable financial losses to the agricultural sector. Although it would be difficult to achieve mass casualties through this means, the threat alone of food or beverages being adulterated with chemical or biological agents can result in immediate loss of revenues, stock valuations, and confidence in the food industry. The public can quickly grow to doubt their government's ability to protect its food supply and public health following an incident of sabotage using chemical or biological agents.

In World War I, German agents led by Anton Dilger infected Allied horses, mules, and cattle with disease-causing bacteria, including *Burkholderia mallei* (glanders) and *Bacillus anthracis* (anthrax). Although the ultimate results of these operations are unknown, these German operations suggest that sabotage using biological agents is within the realm of possibility.

Modern saboteurs would have to find chemicals or organisms that are potent enough to cause damage while also being effective under various conditions. Chemicals in the water system, for example, quickly become diluted, causing little or no harm. Similar challenges exist in terms of using pathogenic microbes or toxins. Cholera, for example, usually requires at least thousands of bacteria to be ingested in order to cause infection.

Despite the difficulties of using chemical or biological agents to conduct acts of sabotage, the threat of such an event occurring remains significant. On February 20, 2002, for example, Italian police arrested four Moroccan nationals for allegedly plotting a chemical terrorist attack on the U.S. embassy in Rome. The suspects were apprehended with approximately 9 pounds of a cyanide compound and with maps identifying the locations of the water pipes that served the U.S. embassy. The substance reportedly in the possession of the would-be attackers was potassium ferrocyanide, a chemical commonly used as an anticaking agent and food additive. Because of its low toxicity in mammals and humans, ferrocyanide was an unlikely choice to cause poisoning, especially in a water system. It is likely the would-be saboteurs simply misunderstood that ferrocyanide would be far less toxic than other cyanide salts.

During the Cold War, both the United States and the former Soviet Union expended great energy and financial resources examining the problem of CBW, particularly the threat of introducing infectious or toxic agents into a water supply. Neither found many candidate agents capable of causing mass casualties, because water treatment reduces the effectiveness of virtually any effort to poison water supplies.

The intentional release of toxic or infectious substances has been of heightened concern since the September 11, 2001, tragedy. Most industrial chemicals are not toxic enough to wipe out whole communities, but under certain circumstances, a sudden release of volatile chemicals near densely populated areas could result in significant casualties. The U.S. government is looking into ways of improving security at industrial sites and defending them against potential sabotage by terrorists, criminals, or other malefactors.

Other forms of sabotage could include the use of radiological materials. Although it is not a very likely prospect, insiders at nuclear power facilities could try to circumvent safety measures and intentionally cause a reactor core to overheat. The disaster at Chernobyl in 1986, for example, was the inadvertent result of engineers attempting to complete a hastily conducted experiment. It ended in an explosion and an intensely radioactive fire. Some 4,000 people died, mostly firefighters who extinguished the burning graphite and others who assisted with the cleanup operations.

Less dramatic and not as effective are sabotage operations involving the contamination of food or beverages with radioisotopes. Here, too, the ultimate danger would be reduced by dilution of the agent in the food, and by the fact that many heavy metals that are radioactive (such as plutonium-239) will pass through the human digestive tract without causing much harm. Other radioisotopes, such as strontium-90, however, pose particular risks because they mimic the properties of calcium and can insinuate themselves into bone tissue. No data thus far have demonstrated that terrorists are contemplating such attacks, although al-Qaeda is reported to be interested in developing so-called dirty bombs (radiological dispersal devices).

—Eric A. Croddy

See also: Agroterrorism (Agricultural Biological Warfare); Al-Qaeda; Bioterrorism; Terrorism with CBRN Weapons

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SALMONELLA

Salmonella is a genus of disease-causing bacteria that could be used as a weapon for sabotage or to produce mass casualties. One species of *Salmonella* in particular—*enterica*—often results in significant disease affecting the gastrointestinal tract. Although the disease-causing *Salmonella* bacteria were recently grouped into the species *enterica* to simplify matters, the nomenclature is still confusing, especially for health care professionals. This species of bacterium, *Salmonella enterica,* is comprised of three main subcategories of distinct organisms, which cause the most significant numbers of illness associated with *Salmonella.* These three serovars (denoted by the capitalized, nonitalicized names following the species designation) are (1) *Salmonella enterica* Typhimurium, (2) *Salmonella enterica* Enteritidis, and (3) *Salmonella enterica* Typhi.

These *Salmonella* bacteria cause disease primarily via ingestion and are not known to spread via aerosols. Therefore, from a weapons of mass destruction (WMD) threat perspective, the only practical manner in which a bioterrorist could use *Salmonella* to cause significant casualties is through the deliberate contamination of food or water. This has been done before, notably in 1984 in Oregon (see below). Still, diseases caused by *Salmonella* have a low mortality rate. In the event of a bioterrorist attack using these types of bacteria, with modern antimicrobial therapy, death rates from *Salmonella* infections should be well below 1 percent.

Among the three *Salmonella* serovars of concern are *S. enterica* Enteritidis and *S. enterica* Typhimurium, the ones that cause salmonellosis (often referred to generically as food poisoning), and *S. enterica* Typhi, the one involved in cases of typhoid (or enteric) fever (not as common, with about 500 cases per year in the United States).

Salmonellosis (Food Poisoning)

S. enterica Typhimurium and *S. enterica* Enteritidis are the most common causes of food poisoning in the United States. Contaminated food and water, particularly as a result of unsafe food handling practices, are the typical sources of these infectious bacteria. Of these two serovars, the Typhimurium serovar is responsible for most cases of food poisoning in the United States. Unlike *S. enterica* Typhi (the cause of typhoid fever), *S. enterica* Typhimurium is also found in domesticated animals, especially those raised for food. This disease is typified by diarrhea, fever, and abdominal cramps, usually occurring within 1–3 days of infection. The course of illness may last up to a week, but in most cases the illness resolves without medical intervention, and diagnosis is not specific enough to warrant antibiotics. Those in risk groups—the elderly, immunocompromised patients, and infants—may, however, develop serious complications that require timely administration of antibiotics. In this group of individuals, the disease may be life-threatening.

If the bacteria spread outside the intestinal tract, antibiotics such as ampicillin and trimethoprim/sulfamethoxazole can be used. As in other common diseases, increased antibiotic resistance in *Salmonella enterica* bacteria can complicate public health efforts. Although some have blamed this on the use of antibiotics in growth feed supplements in agriculture, not all support this view (Hancock et al., 2000).

There are few known cases of individuals or groups deliberately using *S. enterica* Typhimurium as a biological weapon, although one rather spectacular bioterrorist incident involving sabotage using this organism did occur in the United States. In 1984, cult members of the Bagwan Shree Rajneeshee deliberately sickened 751 people with *S. enterica* Typhimurium by contaminating salad bars at local restaurants. None are known to have died as a direct consequence of this attack.

Salmonella Enterica *Typhi*

By 1898, military physicians were among the first to recognize *S. enterica* Typhi as the cause of an insidious infectious disease that could be spread in asymptomatic carriers. (Mary Mallon—pejoratively known as Typhoid Mary—was such a carrier, infecting more than fifty people in New York City during the early 1900s.) Typhoid fever is a serious illness that is only found in humans. As in other types of *Salmonella* infections, typhoid fever is spread via contaminated food or water. Secondary spread is often through the fecal-oral route (e.g., as a result of insufficient hand sanitation, etc.).

Following ingestion of sufficient *S. enterica* Typhi organisms, there is an incubation period of about 1–2 weeks. During this time, the intestinal infection migrates and becomes a systemic disease (bacteremia). High fever, stomach pains, headache, and sometimes a red rash may appear. Unless treated (with antibiotics), typhoid fever can result in death (at a 1–2 percent rate), often due to perforations in the bowel. Traditionally, antibiotics such as chloramphenicol, amoxicillin, and co-trimoxazole have been used to treat typhoid fever. With increased antibiotic resistance found in some *S. enterica* Typhi strains, however, ciprofloxacin and third-generation cephalosporins are currently recommended.

Due to its prevalence around the world, especially before the antibiotic era, typhoid fever has been a dreaded disease. Biological warfare (BW) programs around the world, including those initiated by the United States during World War II, have investigated typhoid fever as a potential threat to military forces. Avner Cohen has made the claim that an Israeli special BW detachment (Hemed Beit) poisoned wells in Palestinian villages with *Salmonella enterica* Typhi (typhoid) and *Shigella dysenteriae* (dysentery) bacteria during the 1948 War of Independence. Data are incomplete to adequately evaluate this allegation. According to the Monterey Institute of International Studies database on terrorist incidents involving chemical and biological agents (1998), in 1972, a group of college students produced 60–80 pounds of typhoid bacteria (*Salmonella enterica* Typhi) culture with the intent to contaminate the water supply in Chicago, St. Louis, and other Midwestern cities. None of these plans was carried out.

The modern threat of *Salmonella*-based weapons is difficult to assess. Factors that aid against mass casualties are increased public health surveillance, ample supplies of antibiotics, as well as the difficulty encountered by the would-be terrorist in culturing and delivering the agent to the intended target(s). Furthermore, even the most serious form, typhoid fever, has an untreated mortality rate of less than 2 percent, which in terms of BW is hardly devastating. At the same time, one cannot discount the possible use of *Salmonella* bacteria by saboteurs as an incapacitating agent, perhaps through the deliberate contamination of food or beverages.

—Eric A. Croddy

See also: Agroterrorism (Agricultural Biological Warfare); Bioterrorism

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SARIN

Sarin (NATO code GB from the first generation "German" nerve agents) was the second deadly G-series nerve agent discovered by the German chemist Gerhard Schräder and his colleagues in 1938. The name *sarin* is attributed to its discoverers—Schräder, Ambrose, Rudriger, and van der Linde. Germany tried to produce the agent on a large scale, but several technical and logistical hurdles prevented it from doing so. Only small quantities were produced by Germany in 1944. The sarin production process is more complicated than the one for tabun, partly due to the use of corrosive agents in sarin's manufacture. Techniques for mass production of sarin were later perfected by the major powers in the years following World War II.

Following inspections by the UN Special Commission in Iraq (UNSCOM) during the 1990s, Iraq claimed to have produced 790 tons of sarin, 30 tons of which were destroyed by UNSCOM, the remainder reportedly having been destroyed by the Iraqis. Sarin was also employed by the Japanese cult Aum Shinrikyo in 1994 at Matsumoto, where 7 people were killed, and during the 1995 Tokyo subway attack, which killed 12 people and injured about 1,000.

Sarin is an odorless, colorless liquid and is highly lethal. Its primary precursors include isopropyl alcohol, hydrogen fluoride, hydrochloric acid, and phosphorus trichloride. Sarin is not a very persistent agent (evaporating very quickly) and it is miscible (soluble) in water as well as organic solvents.

Like other nerve agents, sarin inhibits the action of the acetylcholinesterase enzyme, resulting in the production of excessive secretions, including mucous in the upper airways, and loss of muscular functions. Death may occur either due to respiratory paralysis or asphyxiation from fluid in the upper respiratory tract.

—Anjali Bhattacharjee

See also: Nerve Agents

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SEMTEX

Semtex is the brand name of a high explosive produced in the Czech Republic. The primary ingredient is pentaerythritol tetranitrate, with a plasticizer additive. Semtex was probably the explosive used to destroy the Pan-American Boeing flight over Lockerbie, Scotland, in December 1988.

— Eric A. Croddy

See also: C-4

SHIKHANY

Shikhany, located on the Volga River about 50 miles from Saratov, was selected in 1924 to become a center of Soviet chemical weapons activities. In 1926, a secret facility was established under the code name Tomko to conduct chemical warfare agent work under a secret Soviet-German agreement on chemical weapons production. The Germans used the site to circumvent the provisions of the Treaty of Versailles, which forbade Germany to produce, among other kinds of munitions, chemical weapons. Former chief of the Soviet chemical troops, Major General Nikolai S. Antonov, described the origins of Shikhany and the "Tomko" agreement in this way:

> The military-chemical test facility, "Tomko," was organized in cooperation with Germany in 1926. The creation of these schools and the military-chemical testing facilities took place under conspiratorial conditions. The Soviet-German agreement on joint activities within the framework of "Tomko" was signed in the name of fictitious joint stock companies. For Russia, the joint stock firm was signed as carrying out the "struggle against agricultural pests and the use of artificial fertilizers," while Germany's side of the bargain was described as "the use of raw materials." In the agreement text, howitzers were called "Metal devices," projectiles were called "balls," etc. German personnel were prohibited from making acquaintance with the local population, Soviet military personnel, or other foreign nationals. Nor were Germans allowed to leave the Shikhany region without the agreement of Soviet administrative leadership of Tomko. They were even forbidden to leave for the town of Volsk, located a mere 25 kilometers from their quarters in Shikhany (Antonov, p. 19).

The proving ground continued to conduct joint experiments until 1933, when the Germans stopped collaborating with Soviet scientists. After World War II, two chemical facilities used the same place name: Shikhany 1 officially conducted industrial hazardous chemical work for the State Institute for Organic Synthesis Technologies under the Industry Ministry, but may in fact have been engaged in chemical agent research. Shikhany 2 housed a research lab, included a chemical proving ground, and conducted defensive chemical warfare work. These closed cities, also referred to as Volsk-17 and -18, are about 2.5 miles apart. In 1992, chemical munitions were destroyed at both sites. Western suspicions about clandestine activities at these two facilities were raised, however, when President Boris Yeltsin closed the cities in 1997, denying Western observers access to the area.

Shikhany 1, together with two other sites at Novocheboksarsk and Volgograd, carried out all chemical weapons research in the Soviet Union. Shikhany 2, together with Turkus in Kazakhstan, was the main chemical weapons proving ground in the old Soviet Union. For reasons that included an effort to show Soviet willingness toward transparency during discussions on chemical disarmament with the West, a public demonstration to Western observers of twelve chemical weapons in the Soviet Army's inventory took place on October 3–4, 1987. The Soviet Union declared 40,000 metric tons of chemical agents when it became party to the Chemical Weapons Convention and was to begin destruction of these weapons in 1989. However, lack of funding has cast into doubt how far Russia has been able to proceed with the destruction of its Cold War surplus chemical munitions.

A current controversy tied to Shikhany is Western concern about the pilot production of third-generation nerve agents that many believe was undertaken at the site. Some believe that the Soviet Union produced both unitary and binary third-generation chemical nerve agents. Western press speculations focused on allegations in the Russian press that chemical weapons production and research had not ceased as President Yeltsin claimed in 1990. Shikhany 2 continues to undertake research, development, and testing of chemical agent detection and protection equipment for Russia.

—Gilles Van Nederveen

See also: Novichok; Russia: Chemical and Biological Weapons Programs

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SIMULANTS

Simulants are chemicals or microbes used in simulations to study the physical properties of chemical and biological warfare (CBW) agents. Whether for offensive or defensive applications, simulants have been employed for the research and development of methods in the production, dissemination, defense, detection, and decontamination of CBW agents. By their nature, simulants are nearly always non-hazardous substances that are useful for modeling the behavior of real CBW agents.

In most industrialized nations, CBW simulants are currently being used to prepare and exercise defensive measures, which is considered legal activity. This is in contrast to using CBW simulants to develop offensive delivery systems, which is now illegal per international and domestic legislation in most countries. The line, however, dividing offensive and defensive research when using CBW agent simulants can be blurry indeed.

By using nontoxic CBW simulants, laboratory or even open-air testing can be performed without unnecessary risk to workers or the environment. During the Cold War, the United States, the former Soviet Union, and probably other countries conducted CBW research using both live (that is, real chemical agents) and simulated CBW agents to pursue offensive and defensive research. Sometimes tests using simulants were done with the prior knowledge of the human participants. Other tests—such as vulnerability tests in urban cities—were conducted without the knowledge of test subjects. As both Russia and the United States have agreed to abide by prohibitions on chemical and biological weapons (the 1993 Chemical Weapons Convention and the 1972 Biological and Toxin Weapons Convention), both countries now are permitted to use simulants for defensive purposes only.

Today, there are strict guidelines concerning the permissibility of using simulated CBW agents even under controlled laboratory conditions. The challenge faced by researchers working on defensive systems is to find the appropriate chemical or biological agent to simulate a hazardous material, while ensuring that the simulant is safe for use around humans. Other hurdles also include choosing substances that accurately mimic certain chemical or biological signatures to evaluate more and more sophisticated CBW agent detection schemes.

Chemical Warfare (CW) Agent Simulants

Certain chemical compounds, such as riot control agents, have relatively low toxicities, and some of these agents can be used in their actual form to test gas masks and to conduct CBW defensive training. Experimenting on or near humans using other toxic chemicals—particularly the highly potent nerve agents such as sarin and VX—is now out of the question. In 1961, however, Secretary of Defense Robert McNamara led a review of U.S. military defense posture with regard to CBW, under the rubric of Project 112. This program included the testing of both real and simulated CBW agents. For more than a decade (1962–1973), about 150 separate live agent and simulant tests were conducted on U.S. land- and ship-based personnel (equipped with protective clothing and masks). One program that was part of Project 112 was Shipboard Hazard and Defense (SHAD), conducted on ships in open water.

Some chemicals, such as a radioactive tracer element (phosphorus 32, or P32), were used to track simulants as they were delivered and spread. Similarly, zinc cadmium sulfide (FP) was used to track how other simulants performed as aerosols. In a test named Flower Drum I conducted in 1964, the U.S. military experimented with sulfur dioxide and methylacetoacetate (MAA) as simulants for sarin nerve agent, settling upon the latter for further testing. For VX nerve agent, bis(2-ethylhexyl) hydrogen phosphate (BIS) and diethylphthalate (VX simulant) with fluorescent dye tracer were used, presumably because these chemicals behaved like VX. Similarly, tri(2-ethylhexyl) phosphate or trioctyl phosphate (TOF) were used in later testing as VX simulants. The threat from thickened CW agents, preparations that would increase the viscosity and persistence of nerve agents such as soman, was also addressed by the use of dimethyl methylphosphonate (DMMP) thickened with about 2 percent polymethyl methacrylate colored with 0.5 percent oil red dye. Sarin was also simulated by spraying trichloropropane with pneumatic atomization nozzles.

Today, DMMP is one of the more commonly used nerve agent simulants. DMMP closely resembles actual nerve agent for detection and decontamination tests, without possessing any significant toxicity in mammals. Work being done by the U.S. Department of Energy at Sandia Laboratories in New Mexico includes defensive research in CW agent detection using simulants for G-type nerve agents, VX, and sulfur mustard.

Biological Warfare (BW) Agent Simulants

Because of the requirement to generate aerosols when delivering BW agents, particles of many types of materials including flour, talc, oils, and the like have been used in simulating dissemination patterns. For more realistic testing, however, it has often been necessary to use living, noninfectious agents to simulate aerosol density, decay, and viability of organisms over time.

The more commonly used BW agent simulants have included common and innocuous bacteria such as *Bacillus subtilis* var. *niger*—formerly known as *Bacillus globigii* (BG)—and *Bacillus thuringiensis* or Bt. These bacilli have been used for many years, particularly for simulating *Bacillus anthracis* (anthrax) bacterial spores. Between 1949 and 1968, the U.S. government surreptitiously disseminated BW simulants such as *Serratia marcescens* over a number of American cities, including San Francisco and New York, to test for vulnerability to biological attack as well as to experiment with possible weapons and delivery systems. In 1950, the U.S. military spread BG over about 100 square miles in the United States as part of a vulnerability test. The bacteria causes no infections in people, and can be tracked by collecting spores on culture plates. In 1955, American scientists and military experts began using human volunteers to test the effect of various BW simulants including BG. *Serratia marcescens* (SM) was used in San Francisco during this same period. SM was later implicated in hospital-acquired infections, and its use was discontinued in 1969. Project SHAD also included the use of the common bacterium *Escherichia coli* (*E. coli*), as well as BG and SM in the Half Note test (1966). In the face of the modern threat from bioterrorism, research and development in detection technologies requires extensive use of BW simulants (including the standard *Bacillus subtilis*) in controlled laboratory as well as open-air experiments. U.S. government agencies will likely continue such defensive tests using BW simulants as part of a defensive program for the foreseeable future.

—Eric A. Croddy

See also: Aerosol; United States: Chemical and Biological Weapons Programs

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SINO-JAPANESE WAR

From approximately 1930 to 1945, Japan engaged in a series of military actions against China known as the Sino-Japanese war. After December 1941, China became an ally of the United States and Britain, and the fighting in China technically became part of World War II. However, the character of the fighting in China differed in some respects from that elsewhere in the Pacific: there was much deliberate cruelty against civilians, and the Japanese conducted chemical and biological warfare.

The Japanese conquest of China was often horrifically cruel and destructive, even when using only “conventional” weapons. During a 6-week period in Nanjing in 1937, for example, the Japanese army killed several hundred thousand civilians and Chinese prisoners of war and raped tens of thousands of Chinese women. Urban areas were subject to aerial bombardment with incendiaries.

Japan had adopted an expansionist policy in China following the first Sino-Japanese war in 1895, which led to the colonization of Formosa (Taiwan). The Russo-Japanese War of 1905 further extended Japanese influence into areas of northeastern China (Manchuria) and led to the annexation of Korea. In a series of fabricated “incidents,” Japanese military forces extended overt Japanese rule throughout Manchuria in 1933, and after 1937 throughout much of coastal China.

Japan did not ratify the 1925 Geneva Protocol that outlawed biological warfare (BW) and chemical warfare (CW). In 1930, Japanese military forces used an irritating agent chloroacetophenone (CN) during its suppression of a Formosa-based indigenous rebellion. Especially after 1933, Japan pursued the development of both CW and BW. In hundreds of separate incidents from 1937–1943, the Japanese military forces fighting in China used chemical weapons of the types developed in World War I. These included mustard, lewisite (often in mixtures), and another irritating substance, diphenylcyanoarsine. Chinese military forces lacked gas masks, and so they typically fled when gas was used. Although the United States later assisted in some areas to provide a defensive and offensive capability in CW, for the most part the Chinese lacked an effective chemical arsenal. Thus, the Japanese were able to use CW without having to endure retaliation in kind.

After China became a U.S. ally after the Japanese attack on Pearl Harbor (December 1941), President Roosevelt issued a warning in 1942 to the Japanese that further use of CW against China would be considered a use against the United States and that the U.S. military might retaliate in kind. Fearing the large chemical arsenal held by the Americans, Japan began to limit its use of chemical weapons against the Chinese after U.S. entry into the war in the Pacific.

As Japan faced an onslaught of both Allied and Soviet forces bent on liberating China, Japanese military forces buried up to 1 million or more chemical munitions, mostly along the Sino-Soviet border, in anticipation of warfare with the Soviet Red Army. As a result, the ongoing disposal of chemical weapons abandoned by Japan in China during the 1940s remains a problem today. Pursuant to the 1993 Chemical Weapons Convention (CWC), Japan has agreed to fund, and provide destruction technologies to rid China of, these abandoned chemical weapons.

Biological Weapons Research

In a well-funded program that lasted from approximately 1932 to the Japanese surrender in 1945, Japan researched, developed, and employed biological weapons while occupying mainland China. The primary research organization was called Unit 731, ostensibly a "sanitation" unit located near Harbin, Manchuria. The leader of this program was an ambitious Japanese military officer and microbiologist, Ishii Shiro. In addition to Unit 731, there were multiple satellite BW facilities located in most major occupied Chinese cities.

The program committed horrific crimes against humanity, including deliberately lethal testing on human captives. Field trials against civilians were conducted within these biological weapons research facilities, where victims (usually prisoners of war, or others taken from local villages) were sometimes vivisected. At least 3,000 innocent victims were murdered during biological experimentation by Japanese BW scientists in China. The weapons developed included plague-infected fleas dropped from airplanes over Chinese cities; bombs containing anthrax; and various waterborne pathogens (cholera, typhoid, paratyphoid, dysentery, and glanders), some of which were released into rural Chinese water supplies. Several cities and scores of villages in Zhejiang province in the summer of 1942 were subjected to BW attack with multiple pathogens, resulting in thousands of deaths. As a consequence of Japanese BW activities, infectious disease persisted in some Chinese villages long after the war was over.

Another branch of the Japanese military BW program included a veterinary research and development organization called Unit 100 that did work in agricultural BW. Unit 100 worked on antianimal diseases such as anthrax and glanders, as well as anticrop agents. Following the U.S. warning regarding the use of CW, Japanese use of biological weapons in China became less frequent.

After the Japanese surrender, the Soviets captured some Unit 731 scientists and related personnel. A dozen of these individuals were tried and convicted of war crimes at a court held in Khabarovsk in 1949. These individuals, however, were not executed but given various jail sentences, and most of them returned to Japan by the late 1950s. Other principal Japanese scientists and staff involved in the BW activity were granted amnesty for their war crimes by the United States in exchange for their technical data of BW effects on humans. At the time, concerns regarding the Soviet Union and its possible development of biological weapons were an important factor in this controversial decision.

Although technically not part of the Sino-Japanese War, the Japanese also mounted a BW attack during a short but vicious border war at Nohoman in 1939. This attack had the aim of contaminating water supplies used by Soviet forces. This was perhaps the first tactical antipersonnel BW attack of modern times. The effect on the Soviet forces is unknown, but the attack did not prevent a rout of the Japanese forces, and apparently it caused many unintended casualties among the retreating Japanese army.

—Martin Furmanski

See also: Japan and WMD; Unit 731; Wushe Incident

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SKATOLE

Skatole is an olfactory agent. Hardly a weapon of mass destruction, olfactory agents nonetheless continue to be researched for their possible role as crowd control agents and in combat. Olfactory agents produce foul odors to harass the enemy; in civilian contexts, they could be used by authorities to persuade unruly mobs to disperse.

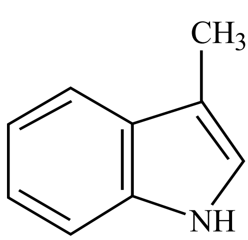
Military manuals dating back at least to the nineteenth century European militaries include stinkball recipes calling for a mixture of sulfur, horse hooves, and other materials that produced a stench. In World War I, foul-smelling substances were investigated to mask the odor of truly toxic chemical warfare agents such as mustard, so as not to alert the enemy to the presence of the toxic agents. These olfactory agents were also used simply to cause distress for the opposing forces, by causing panic about the possible presence of more lethal gases or to force troops to put on protective gear and masks.

N-butyl mercaptan—the essence of skunk—is one such compound mentioned in literature on chemical warfare (CW) during World War I.

During the now-defunct offensive U.S. chemical weapons program, nasty-smelling compounds including derivatives of skatole (3-methyl 1H indole), a foul-smelling substance akin to feces or rotting offal, were investigated. The relative ease of protecting against such odors (e.g., wearing masks) and the fact that motivated opponents would not be deterred by aversive odors alone led planners to abandon research into olfactory agents.

In the United States, there have been hundreds of recent cases involving "noxious chemical vandalism" on abortion clinics or other targets by activists. In most, if not all, of these, butyric acid was used. Butyric acid is the active compound that produces the foul odor in rancid butter, and it can be irritating to the skin and eyes in high concentrations.

Figure S-1: Skatole olfactory agent



Generally speaking, however, butyric acid and other olfactory agents are not very toxic.

—Eric A. Croddy

See also: Psychoincapacitants; Riot Control Agents; CS

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SMALLPOX

Smallpox is a contagious, infectious viral disease of humans that causes death in about 30 percent of its victims. (*Contagious* refers to a disease that is communicable through contact, whereas *infectious* is defined as "capable of causing infection." Therefore, some organisms can be infectious but not contagious, i.e., not capable of being passed from person to person.) Motivated by hundreds of millions of smallpox deaths in the twentieth century, the World Health Organization (WHO) initiated a worldwide vaccination campaign that continued through the 1970s. In 1980, the WHO officially certified the elimination of smallpox from the globe (the last case of smallpox in the United States occurred in 1949). This was due to the fact that smallpox is a viral disease that only infects humans. There are no other animals known to carry or suffer from the disease.

Although the disease was officially eliminated in 1980, concerns have emerged about state or terrorist use of smallpox as a weapon. It is known that the Soviet Union ran a program to weaponize smallpox, and it was reported in the fall of 2002 that Iraq, North Korea, and France may also retain samples of the virus. In addition, terrorists are known to be interested in biological weapons. As a result, the United States government has stockpiled enough vaccine to immunize the entire U.S. population; however, due to the potential for side effects from the vaccine and the need to have health care workers available to combat smallpox in the event of an

Some first responders in the United States received the smallpox vaccine in 2003. (Kim Kulish/Corbis)

attack, the current U.S. vaccination policy is to vaccinate only selected health care workers.

Medical Aspects

The Variola virus, a member of the poxvirus family, causes smallpox. A virus is essentially a package of genetic material in a shell made up of protein, which may be surrounded by a protein envelope. Viruses cannot reproduce on their own and must invade another organism to reproduce and grow. Smallpox can take two forms: Variola major, the predominant form, and Variola minor, a less common and less severe form that causes death in less than 1 percent of cases.

A Variola major infection can manifest in four ways. In 90 percent or more of cases, patients experience "ordinary" infection (see below). Other types include modified (a milder infection that normally occurs in previously vaccinated individuals), a malignant form (flat), and hemorrhagic, a particularly dreadful outcome involving bleeding in skin tissues. Both the malignant and hemorrhagic forms of smallpox are nearly always fatal. As with many viruses, there is no specific treatment for smallpox, although prompt administration of vaccine before symptoms appear can prevent the disease.

In the past, natural smallpox was usually spread through close contact of less than 6 feet, with an infected individual spreading aerosolized viral particles, or through contaminated clothing or bed linens. There were occasional cases of transmission over larger distances. The average patient (ordinary infection) developed a fever, experienced severe aches, and became completely exhausted within 12–14 days (within a range of 7–17 days after infection). One to three days after the onset of fever, a rash consisting of small, solid, raised lesions developed on the face and extremities, and to a lesser extent, on the trunk. As the rash progressed, the small lesions filled with fluid and became inflamed, pus-filled, blisterlike, and typically extremely painful. Eventually, the lesions crusted over and formed scabs, which often scarred the patient severely. Death generally occurred during the second week in about 20 to 30 percent of cases, depending on the strain and whether good supportive care was given.

Smallpox as a Weapon

In the second half of the twentieth century, the Soviet Union weaponized Variola major. The collapse of the Soviet Union has caused concern that unsecured stores of biological (and other) weapons might be stolen or sold to terrorists, or that former Soviet scientists who are now out of work might share their expertise with other countries or terrorist organizations for pay.

Smallpox is of particular concern because of the lethality of the disease and the historic development of Variola major as a weapon by the Soviets. Smallpox was chosen as a viable biological weapon because it is a hardy virus, it is highly infectious through the air, it can survive explosive delivery, and it causes a debilitating, disfiguring disease with high mortality. One strain chosen by the Soviets, known as India 1967, was particularly virulent. It killed more than 30 percent of those infected, retained virulence when stored for long periods, and was extremely stable in aerosol form. Additional stabilizers, filling agents, and chemicals extended the shelf life of weaponized smallpox.

The Soviets are said to have stored some twenty metric tons of weaponized smallpox, although all but a few samples stored in Russia (and some kept by the Centers for Disease Control in Atlanta) are said to have been destroyed. There is no evidence in the unclassified literature that other countries or any terrorist groups have developed or acquired a smallpox weapon, and smallpox has not been used as such in modern times. Except for a possible outbreak caused by Soviet weapons testing in the 1970s (Aralsk), there is no experiential data on the course of a man-made smallpox epidemic. Discussions on the course of a smallpox epidemic thus reflect the characteristics of a natural epidemic, which may or may not be different from the effects a smallpox attack would have, especially with a weaponized form of the disease.

Complications in the Event of an Attack

If smallpox were used as a weapon, issues that may arise include recognition and diagnosis in infected patients; a lack of laboratory capacity to test samples; the severity of adverse reactions to the preventive vaccine; the low level of population immunity in the United States; and the difficulties in mounting a quick, widespread vaccination campaign.

Recognition and diagnosis of smallpox may be difficult because many health care workers have little experience with smallpox. In addition, the medical community is unsure about smallpox severity and presentation in individuals vaccinated more than 10 years ago. Smallpox can be confused with other diseases and has been confused with chicken pox in the past. Smallpox lesions develop on the same timeline and appear identical on all parts of the body at a given time; however, they are deeper than chicken pox lesions, and smallpox typically appears on the face and extremities whereas chicken pox lesions are usually concentrated on the trunk.

Atypical presentations of smallpox present additional problems. Malignant (flat) smallpox may occur in about 5 percent of patients, and was 95 percent fatal in non-vaccinated persons. It presents with an insidious, more velvety type of rash. The hemorrhagic form appears in about 3 percent of smallpox cases. In the past, all hemorrhagic cases, which occur more frequently in pregnant women, have resulted in death. The incubation period in these cases is somewhat shorter, and the patient is likely to die by the fifth or sixth day after onset of rash.

Laboratory confirmation of smallpox infection can only be done in a few locations in the United States due to the need for specialized equipment and personnel. Definitive testing may take time. Smallpox infection can be rapidly identified in the laboratory using electron microscopy; however, definitive identification and characterization requires growth of the virus in cell culture or on an egg membrane followed by characterization with biologic assays. The specialized equipment and personnel must be contained in biosafety level 4 facilities (*see* Protective Measures: Biological Weapons). There are only five such facilities in the United States: the Centers for Disease Control and

Prevention in Atlanta; the United States Army Institute for Infectious Disease at Fort Detrick, Maryland; the National Institutes of Health in Bethesda, Maryland; Southwest Research Institute in San Antonio, Texas; and the University of Texas Medical Branch in Galveston.

Vaccination side effects can be severe, and because the risks of a natural outbreak of smallpox are negligible, routine administration of Vaccinia is now only given to U.S. military personnel and certain health care professionals. The smallpox vaccine is made up of live Vaccinia virus. Although this virus is not normally deadly for humans, because the vaccine virus is alive, it can cause severe complications. On the positive side, immunization before exposure and up to 5 (or possibly 7) days after exposure will almost certainly prevent death, and early vaccination—within 1 to 4 days following exposure—will prevent the disease. Expected complication rates are commonly quoted at between one and three deaths and approximately fifty side effects per 1 million people vaccinated; however, based on U.S. surveillance, the actual death rate was five per million and as high as eight per million during vaccination campaigns in previous smallpox outbreaks.

Severe side effects from smallpox vaccination, although rare, may include postvaccinal encephalitis (swelling of the brain) and progressive vaccinia (spread of the vaccination lesion to surrounding tissue). In the past, postvaccinal encephalitis impacted three people per million first-time vaccinees and resulted in death in 40 percent of those cases. Those who survived often experienced permanent neurological damage. Progressive vaccinia occurs among those who are immunosuppressed. A passive form of vaccination using Vaccinia immune globulin (VIG) can be used to treat complications caused by the active Vaccinia inoculation.

In addition to the danger posed by the vaccine to the person receiving the vaccine, there is a period of about 2 weeks during which a newly vaccinated individual can transmit the Vaccinia virus to unvaccinated individuals, with the immunocompromised being the most vulnerable to this.

In addition, because the vaccine has not been commonly administered in the United States for the past 30 years, the effect of the health status of the population on the number and severity of side effects is unclear. There has been a significant increase over time in the number of immunocompromised people, such as those with HIV/AIDS, people undergoing chemotherapy, the elderly, and others who are more likely to experience more severe side effects. The stocks of VIG are very low, reportedly only enough to treat 700 people in 2002.

The United States has a very low level of herd, that is, collective immunity because childhood vaccination was stopped in 1972. Therefore, most individuals in the United States are either unvaccinated or were vaccinated more than 30 years ago. In the past, vaccinations for those working with smallpox were recommended once every 3 years, and the general population was instructed to receive boosters each decade. The efficacy of the vaccine after time periods longer than 10 years is not well studied, but experts generally agree that people vaccinated more than 10 years ago may be more likely to experience a milder atypical form of smallpox and are less likely to die from the infection.

Smallpox vaccination normally takes effect in about 80 percent of the recipients. Repeat administration may be required to ensure that the vaccine "takes," that is, elicits sufficient immune response for protection against smallpox exposure. Vaccination logistics are complicated because vaccination requires special bifurcated needles and the expertise to use them. Because the disease resulting from the live vaccine can be transmitted for 2 weeks, newly vaccinated individuals should not expose themselves (without specific protections including carefully applied bandages) to those who are immunocompromised, to pregnant women, or to people with eczema for at least 2 weeks after vaccination, because these individuals are at risk for developing severe complications from secondary infection with the Vaccinia virus. In an actual event of a smallpox outbreak, however, the risks of acquiring the disease are obviously much greater. For people with eczema and pregnant women, if suspicions are well-founded that either group were exposed to Variola major, combined vaccination of these individuals with Vaccinia and VIG would be indicated.

The Threat

Although there is great concern about a potential smallpox attack, the likelihood of a smallpox attack by terrorists or a state is extremely low—though not zero. There are several reasons for this. First, the virus causing smallpox is difficult to obtain. Starting in 1975, the Smallpox Eradication Unit of the WHO attempted to identify all laboratories that held samples of smallpox by (1) contacting every country and territory and requesting a list of laboratories that maintained stocks of the virus, (2) searching the literature, and (3) contacting laboratories directly. As a result, there are only two remaining known stocks of smallpox in the world. One is located at the Centers for Disease Control and Prevention (CDC) outside of Atlanta, Georgia, and the other is at the State Research Institute of Virology and Biotechnology (VECTOR) near Novosibirsk in Russian Siberia. It has been suggested that no state would want to give a weapon such as smallpox to a terrorist group because of its potential to have unplanned effects, such as killing unintended victims.

Second, the virus is not easy to grow and weaponize. It is a lethal virus, making it dangerous to work with. Any terrorists attempting to weaponize it would have to be immunized against smallpox, a practice stopped in most countries in the late 1970s and early 1980s, with a few exceptions for researchers and others. Therefore, terrorists would first have to acquire some of the vaccine. Also, terrorists capable of growing and weaponizing smallpox would be a very unique commodity. At a bare minimum, the terrorists would need special equipment to work with such a pathogen, and for most terrorist organizations, it would take some effort to acquire the equipment (although less effort than obtaining the virus itself).

Third, terrorists tend to prefer predictable results, and the consequences of releasing smallpox are not well understood. It has been decades since such a virus was released in such a naïve (unimmunized) population, and the population health and demographics have changed in other ways as well since the smallpox vaccine was widely used. The United States is one of the healthiest countries on Earth, and releasing the virus against it might have a boomerang effect, impacting more on the countries of origin of the terrorists than on the United States and its allies. Finally, terrorists or an enemy state may not want to provoke the likely complete and devastating reaction that the United States might have to such an attack.

—Jennifer Brower

See also: Aralsk Smallpox Outbreak; Bioterrorism; Russia: Chemical and Biological Weapons Programs; Vaccines; VECTOR: State Research Center of Virology and Biotechnology

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SOMAN

Soman is a lethal nerve agent also referred to as GD for the "German" series of first-generation nerve agents. It was synthesized by Richard Kuhn in 1944 and had undergone laboratory experimentation by German military chemists by the end of World War II. Being more fat soluble and able to penetrate the skin, soman is far more lethal than sarin or tabun. Soman has been thickened in the past by U.S. and Soviet militaries (resulting in a product called TGD) to improve its dissemination properties as a liquid, as well as increasing its persistency. Soman is a colorless liquid with a "fruity" odor, sometimes described as resembling that of camphor.

Soman is produced in a similar batch process to sarin. The lack of ready precursors prevented Iraq from weaponizing this nerve agent, and thus it turned to others such as tabun (GA) and sarin (GB). Soman is less stable in storage than tabun or sarin but is much more rapid in its lethality: Death can occur within 15 minutes of exposure. Upon exposure to soman, some antidotes (such as selected oximes) are not as effective as they would be for other nerve agents.

Like other nerve agents, soman works by inhibiting acetylcholinesterase (AChE), resulting in the production of excessive secretions and loss of muscular function. Death may occur either due to respiratory paralysis or asphyxiation from fluid in the upper respiratory tract.

—Anjali Bhattacharjee

See also: Nerve Agents; Organophosphates; Oximes

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SOUTH AFRICA: CHEMICAL AND BIOLOGICAL WEAPONS PROGRAMS

Toward the end of 1981, the South African regime established a covert chemical and biological weapons program code-named Project Coast (later Project Jota). The project was ostensibly created for defensive purposes, in response to reports that government and Cuban military forces in Angola were possibly using chemical weapons against South African Defense Force (SADF) troops and their allies. The program, however, also had offensive features and capabilities. The apartheid-era government viewed itself as the target of a "total onslaught" by Soviet-backed Marxist guerrillas and regimes in neighboring states as well as by black nationalists at home, and to meet this all-encompassing "red-black danger," it was willing to use any means at its disposal to defend itself. It was in this highly charged political and military context that Project Coast was secretly initiated under the aegis of SADF Special Forces (SF).

Project Coast, like the foreign CBW programs upon which it was supposedly modeled, included both a chemical warfare (CW) component and a biological warfare (BW) component. Both the CW and BW programs in South Africa consisted of one principal production facility and several other facilities that, for administrative, security, or technical reasons, carried out specialized research, testing, or production tasks. Although these two main production facilities (one for CW and one for BW) were ostensibly private companies that did commercial contract work for industry—a "cover" that facilitated their recruitment of top scientists and their acquisition of materials overseas—they were in fact SADF front companies that worked primarily on "hard" (military) projects and only rarely on "soft" (commercial) or in-house (researcher-generated) projects.

The primary CW facility was Delta G Scientific (Delta G), a large research and production complex located in Midrand. Its staff of about 120 had the ability to make virtually any synthetic chemical, but their efforts were focused on various military projects geared toward the preservation of public order. These included (1) the large-scale production of chemical irritants and incapacitants used for crowd control, such as CS and CR tear gas; (2) the relatively small-scale production of various illegal mind-altering narcotics in an effort to develop and test their potential viability as "calmatives"; (3) a peptide (complex of amino acids) synthesis program, which was apparently working to enhance the physiological effects of bioregulators, novel agents that could induce dramatic changes in victims; and (4) a CW research and analysis program, which manufactured small quantities of toxic substances on demand.

The main BW facility was Roodeplaat Research Laboratories (RRL), a large, sophisticated research, testing, and production complex located north of Pretoria. Its staff of around 70 worked primarily on three types of military projects: (1) a toxin R&D program headed by Managing Director André Immelman, whose goal was to develop and test lethal BW and CW agents that were untraceable; (2) a fertility program, headed by Dr. Riana Borman, whose purpose may have been to limit the growth of the black population; and (3) a BW program linked to new developments in the genetic engineering field, headed by Dr. Mike Odendaal, whose aim was to develop antibiotic-resistant strains of pathogens by combining different biological agents.

Although there was no large-scale production or weaponization of either offensive CW agents at Delta G or offensive BW agents at RRL, a plethora of toxic substances were acquired, researched, tested, or prepared at these facilities. At Delta G, these substances included BZ and mustard and a wide array of other toxic chemicals, whereas at RRL they included anthrax bacterium, botulinum toxin, *Brucella* bacteria, cholera bacterium, *Clostridium perfringens, Escheria coli,* plague bacterium, *Salmonella* bacteria, HIV-infected blood, and snake venom, as well as small quantities of CW agents such as mustard, sarin, tabun, VX, and various other toxic chemical compounds. Some of the two firms' products were then reportedly tested at the pyrotechnical labs at Special Forces (SF) headquarters, the South African Police's (SAP) Forensic Sciences Laboratory, or other facilities at various state companies, partially state-run companies, private companies, and universities.

The apex of the official chain of command for both the CW and BW components of Project Coast was the president of the Republic himself (P. W. Botha), who, under the militarized National Security Management System established in August 1979, exercised his authority primarily through the State Security Council rather than the cabinet. The entity that officially managed Project Coast was known as the Coordinating Management Committee (CMC), which typically met two to four times per year and normally comprised the SADF chief, the Surgeon-General (who was also the head of the South African Medical Services [SAMS]), the Chief of Staff (COS) for Intelligence, the COS for Finance, representatives from the state armaments corporation, personnel from the Auditor-General's office, and a CMC secretary. Directly under the auspices of the CMC, three ad hoc "work groups" were formed to deal with specialized technical, financial, and security matters.

The Project Officer (Dr. Wouter Basson), who operated under the control and direction of these "work groups," had as his appointed task acting as an intermediary between the CMC and the directors and scientists at the various CBW facilities.

Project Coast may well have had some sort of parallel, unofficial command structure that operated alongside the official CMC chain of command. Former Surgeon-General Niel Knobel claimed that Basson was often either doing things on his own initiative or, as Basson himself later acknowledged, being given operational instructions directly by other parties, including the Defence Minister, the head of the SADF, the Commanding Officer of the SF, the COS Intelligence, the Director-General of the National Intelligence Service, the Commissioner of the SAP, and possibly members of the State Security Council or cabinet whom he encountered while providing them with medical treatment. After receiving at least some of his orders from these powerful figures, Basson then passed instructions on—always verbally—to Project Coast scientists and select members of covert SADF or SAP units with a need to know, frequently without informing his nominal superiors on the CMC.

On two or three occasions, SF elements may have used conventional CW or BW agents, such as BZ, against Mozambican soldiers and cholera to poison Namibian water supplies. The most characteristic feature of the South African CBW program, however, was its development, testing, and use of a wide array of hard-to-trace toxic agents to assassinate individual "enemies of the state." As insider testimony and the notorious RRL "sales list" of 1989 indicate, several of the highly toxic substances produced at both Delta G and RRL were apparently deployed by clandestine SADF and SAP "death squads," mostly the SF's Civil Co-Operation Bureau (CCB) and the SAP Security Branch's Counterinsurgency section (later renamed C10) housed at the Vlakplaas base, in covert assassination operations.

Members of certain elite Rhodesian counterinsurgency units who had previously deployed toxic chemicals or biological agents against guerrillas during the Rhodesian civil war were later incorporated into SADF special operations units (such as the SF and its Delta 40 and Barnacle "hit teams," the predecessors of the CCB) or the SAP's counterinsurgency forces (such as the Koevoet [Crowbar] unit). There is no doubt that high-ranking officers within the SADF and SAP, and other "securocrats" within the government, were generally aware of these murderous activities, many of which they in fact authorized.

On the verbal instructions of Basson, RRL's research and development director secretly transferred a host of highly toxic chemicals and freeze-dried pathogens that had been produced at either Delta G or RRL—and thereafter stored in a refrigerator inside a fireproof and bomb-proof walk-in safe in his own office—to military and police personnel through various channels. The actual substances included lethal chemicals such as Aldicarb, brodifacum, cantharidin, colchamine, cyanide, digoxin, methanol, monensin, paraoxon, paraquat, phencyclidine, phosphide, silatrane, sodium azide, thallium, and Vitamin D3; biological agents such as anthrax spores, botulinum toxin, *Brucella* bacteria, *Salmonella* bacteria, mamba venom, and bottles of cholera bacterium; and a wide variety of foodstuffs, beverages, household items, and cigarettes that had been contaminated with these poisons. The evidence suggests that several of these toxic materials, items, or devices were used to murder or sicken troublesome prisoners, guerrillas in neighboring countries, untrustworthy members of the security forces, or activists in the African National Congress (ANC) and other South African opposition groups.

Later, in the course of the extraordinary political transition of the early 1990s during which the apartheid regime reluctantly but peacefully ceded power to a new ANC-led government, the activities of Project Coast were gradually phased out and exposed. In January 1997, Basson was arrested in a sting operation for possessing thousands of capsules of the illegal drug MDMA (Ecstasy) that had apparently been manufactured at Delta G, ostensibly for use as a potential "calmative." Following Basson's arrest, the police discovered several trunks full of project documents that he had secretly whisked away and stashed with friends or in storage facilities, a small but important portion of the corpus of documents that was supposed to have been physically destroyed after being copied onto secured CD-ROMs.

Basson was indicted by the state for murder and a host of other crimes that he had allegedly committed during the period when he served as project officer for Coast. During the course of this trial, as well as at the earlier hearings held by the Truth and Reconciliation Commission, a wealth of detailed information emerged regarding the true scope and nature of South Africa's CBW program. To the astonishment of most observers, however, Basson was acquitted in April 2002 of all the charges filed against him, and disillusioned government prosecutors now appear to have abandoned their plans to file an appeal for a new trial.

While some analysts regard South Africa as a model for other states that might decide to dismantle their WMD programs, the termination of the country's CBW program was by no means as transparent as that of its nuclear program. Basson's assurances that the remaining stocks of Coast-related CW and BW agents were destroyed were never independently verified, virtually everyone responsible for the crimes associated with the program escaped punishment, and, as recently as 2002, at least one former Coast scientist was involved in a scheme to sell lethal BW agents to foreign parties.

—Jeffrey M. Bale

See also: Bioregulators; Riot Control Agents; Sabotage

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SOUTH KOREA: CHEMICAL AND BIOLOGICAL WEAPONS PROGRAMS

Although it exists in uneasy armistice with North Korea, a proliferator of nuclear, biological, and chemical weapons, South Korea has foresworn weapons of mass destruction. In the 1970s, South Korea flirted with, then abandoned, a nuclear weapons program, but it retains the technical capacity to produce nuclear, as well as chemical and biological, weapons. South Korea is a signatory to several major nonproliferation treaties, including the Nuclear Nonproliferation Treaty (NPT), Chemical Weapons Convention (CWC), and Biological and Toxin Weapons Convention (BTWC). South Korea has adopted a policy of a "nuclear-free Korean peninsula."

In 1991, President Roh Tae-Woo ruled out South Korean acquisition of chemical and biological weapons and pledged to participate in international efforts to eliminate these weapons. After ratifying the CWC in 1997, South Korea acknowledged possessing a chemical weapons production facility as well as several tons of chemical weapons. Honoring its CWC obligations, South Korea is currently investigating means of destroying chemical munitions at a disposal site in Yongdong

South Korea joined the Australia Group in October 1995, and ratified the CWC in April 1997. Due to the threat of North Korean biological weapons, South Korea conducts research and development for defensive biological warfare and possesses vaccines against anthrax and smallpox. Although South Korea possesses a well-developed pharmaceutical and biotechnical infrastructure, there is no evidence that Seoul has an offensive biological weapons program.

—*J. Simon Rofe*

See also: Korean War; North Korea: Chemical and Biological Weapons Programs

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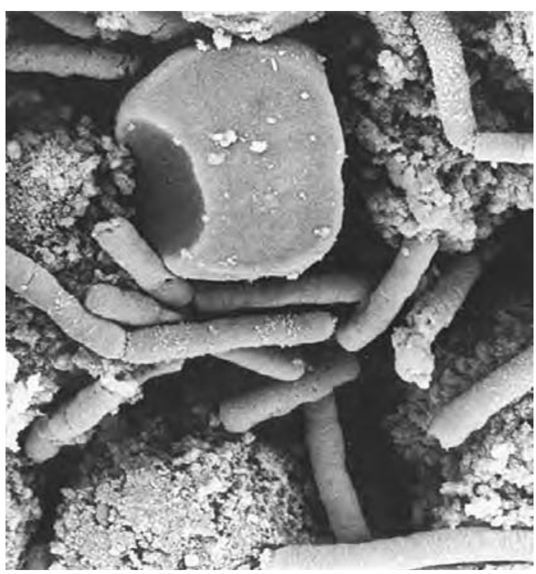
SOVIET UNION: CHEMICAL AND BIOLOGICAL WEAPONS PROGRAMS

See Biopreparat; Russia: Chemical and Biological Weapons Programs

SPORE

Some bacteria convert to a dormant and inactive form called a spore under anaerobic (lacking in oxygen) conditions or when little nutrition is available. Usually, a spore is stable and is resistant to heat, drying, freezing, chemicals, and radiation because it is protected by an exosporium (an outer envelope), a spore coat, and a skin coat. Spores are metabolically



Bacillus anthracis (anthrax) under electron microscopy. (Ant/Corbis Sygma) inactive, which makes it unlikely that they will ingest poisonous materials.

The anthrax (*Bacillus anthracis*) spore has several qualities that make it an ideal biological weapon. When anthrax is converted to a spore, it becomes an extremely stable particle, resistant to many chemicals and environmental stress factors such as heat, moisture, and extremely cold weather. In the nineteenth century, cattle were imported from India to Australia for beef consumption, but anthrax disease broke out among them. These cattle were slaughtered and buried. After 130 years, the ground in that area was broken for construction purposes, and anthrax disease spread again, illustrating the extreme stability of spores.

When dormant and inactive, spores of anthrax enter a person or an animal through inhalation, through wounds in the skin, or orally. Once inside the body, the spore converts into the active form of anthrax bacteria, causing infection in humans or animals.

—Anthony Tu

See also: Aerosol; Anthrax

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STABILIZERS

Due to the inherent chemical and physical properties of some chemical and biological warfare (CBW) agents, stabilizers are sometimes used to prolong shelf life, enhance dissemination patterns, and increase the overall effectiveness of these agents when deployed in weapons systems.

In the case of chemical warfare (CW) agents, the primary technical hurdles faced by weapons engineers have involved problems caused by acidic by-products and chemicals spontaneously combining into unwanted byproducts (polymerization). Overly high or low pH levels in a variety of CW agent mixtures can not only degrade the agent, but can corrode vessels in both storage and weapons platforms. In the case of polymerization, molecules can spontaneously attach themselves to one another, changing the properties of the agent or even causing an explosion. Sulfur mustard is notorious for its ability to polymerize, as is hydrogen cyanide. Nerve agents—particularly the G-series agents that contain fluorine (e.g., sarin and soman)—can be prone toward this same instability. Other agents are relatively stable and require little additional processing.

Chemical stabilizers such as neutralizing compounds can prevent the degradation of CW agents. In 1995, for example, Iraqi Scud warhead fragments showed degradation products of VX and dicyclohexyl carbodiimide, a well-known stabilizer for munitions containing VX. Other compounds such as trimethylamine can be used for acidic nerve agents. For the first mass-produced nerve agent, tabun, German chemists added chlorobenzene to increase its storability.

Biological warfare (BW) agents are biologically active but for the most part chemically inert substances or living organisms. In most cases, when it comes to stability of biological agents, water is the main culprit, causing physical manifestations (caking) and allowing other microbes and enzymes to spoil the product. Freeze-drying (or lyophilization) and the addition of certain neutral stabilizers have been used in the past to help correct this problem. Anti-caking agents (silicon dioxide-based powders) and other compounds to maintain loose particles have also been employed in certain BW preparations.

Although only indirectly related to the problem of stabilizing CBW agents, liquid rocket propellants also sometimes require the addition of chemicals to maintain the structural integrity of storage vessels as well as rocket components. In the case of the oxidizer (the oxygen containing part of the fuel mixture) called inhibited red fuming nitric acid (IRFNA), hydrogen fluoride (and other compounds) has been used to keep the acid from decomposing its metal containers. It is thought that hydrogen fluoride forms an insoluble metal complex that prevents corrosion of the inner wall of the vessel.

—Eric A. Croddy

See also: Chemical and Biological Munitions and Military Operations

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STAPHYLOCOCCAL ENTEROTOXIN B

The bacterium *Staphylococcus aureus* produces a number of toxic proteins that are considered exotoxins because they are excreted from the cell. These proteins generally act on the intestines and are thus also referred to as enterotoxins. Natural exposure to *Staphylococcus* toxins generally results in food poisoning or nonmenstrual toxic shock syndrome. Due to their profound effect on the immune system, these proteins are commonly referred to as superantigens.

Of these toxic proteins, staphylococcal enterotoxin B (SEB) is the most studied for its ability to achieve the desired effect at very low quantities. The offensive biological weapons program of the United States pursued SEB as an incapacitant in the 1960s. SEB proved to be stable, easily aerosolized, and able to cause systemic damage including multiorgan failure. Furthermore, the agent was more attractive than chemical equivalents because a smaller amount was necessary to get the desired effect. Although exposure to this agent most frequently results in a temporary incapacitating illness, inhalation of very high doses can lead to shock or death.

Most cases of ingested toxin can be linked to improperly handled food products and often traced back to a specific setting where contaminated food was consumed. In the 1960s, research was conducted by the United States at Camp Detrick (now Fort Detrick), Maryland, which included offensive use of SEB (code-named PG) as an incapacitant. These stockpiles were destroyed between May 1971 and May 1972 when other U.S. chemical and biological agents were destroyed. It has been reported that Russian biological weapons programs involved research into using SEB as a toxic agent.

Technical Details

Staphylococcal toxins can cause classic food poisoning. These toxins are produced by *Staphylococcus aureus* bacteria present in unrefrigerated meat, dairy, and bakery goods. When ingested, the toxins are usually confined to the intestines and cause diarrhea and vomiting. When present systemically, or throughout the body, toxic shock syndrome can result.

SEB is a relatively stable compound that is easily soluble in water, is resistant to temperature fluctuations, and can withstand boiling for several minutes. The toxin can be produced by bacteria cultivated in culture media, where the toxins can be excreted and harvested. When freeze-dried, SEB can be stored for more than a year.

SEB is classified as an incapacitating agent, as most cases are not lethal but cause profound illness within a short incubation time. The incubation time after ingestion of SEB varies from 1 to 8 hours (rarely, up to 18 hours) and results in the abrupt onset of acute salivation, intense nausea, vomiting, cramping abdominal pain, and diarrhea. Fever and upper respiratory distress are not seen in ingested cases. These symptoms are usually self-limiting and resolve in about 8–24 hours, but high levels of exposure can lead to septic shock and death if left untreated. Treatment consists of administration of antihistamines, and antibodies (gamma globulin) may also increase survivability.

Aerosol exposure manifests itself in a different manner. The incubation time from airborne exposure is 1–6 hours. After 3–12 hours, a high fever (103–106° F), chills, headache, myalgia (muscle aches), and nonproductive cough may appear. Shortness of breath and chest pains may appear in some patients. The fever can last 2–5 days, and the cough may persist up to 4 weeks. Supportive therapy (in addition to the use of antihistamines and passive antibodies) is recommended.

Diagnosis of SEB exposure can be challenging, as the early symptoms mimic many naturally occurring diseases such as influenza, adenovirus or parainfluenza. Additionally, early clinical manifestations can be similar to those of inhalation anthrax, tularemia, plague, or Q-fever. However with SEB, the respiratory signs and symptoms generally become stable more rapidly as the toxin is cleared from the system.

There are a number of laboratory tests to determine exposure that can be used during the first 6–12 hours. Nasal swabs, induced respiratory secretions, and blood or urine analysis can be useful. Most patients will develop a significant antibody response by 6 days after exposure.

Treatment for enterotoxin exposure is limited. Generally, supportive care and close attention to oxygenation and hydration are adequate. In severe cases, breathing assistance may be necessary. No vaccine is available.

There are no known stockpiles of weaponized *Staphylococcus aureus* toxins. Incidences of ingested toxins due to improperly handled food, however, are common.

An attack with an aerosolized SEB weapon would be unlikely to lead to significant mortality, but 80 percent or more of those exposed to the toxin could be incapacitated for 1–2 weeks. This ability to cause casualties, even if nonfatal, makes the toxin a candidate for weaponization. Additionally, SEB could be used to sabotage food or small-volume water supplies.

—Elizabeth Prescott

See also: Agroterrorism (Agricultural Biological Warfare); Bioterrorism; Toxins (Natural)

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STEPNOGORSK

Stepnogorsk was a key Soviet military center that housed the largest biological weapons production complex in the world. Stepnogorsk, established in 1964 in northern Kazakhstan, never appeared on any Soviet maps. It has been referred to as Makinut-2, Tselinograd-25, or Aksu. The area around Stepnogorsk includes the Tselinny Gorno-Khimichskii Kombinant (TGK) mines and refinery, facilities for the extraction of uranium ore, and the Scientific Experimental and Production Base (SNOPB).

SNOPB, the most strategically important of all the facilities near Stepnogorsk, was a biological weapons facility ostensibly constructed as the commercial biotechnology plant Progress in 1982. This facility played an important role in the Soviet Union's plans for the mobilization of "total war." SNOPB was under the authority of Biopreparat and was designed to be one of the six plants in the Biopreparat system for large-scale production of biological weapons, should the Soviet Union decide to mobilize for total war. The facility specialized in the production of anthrax and might have been able to produce anthrax at the rate of 300 metric tons over 10 months. In 1988, a research team at SNOPB led by Kanatjan Alibekov discovered the Soviet Union's most lethal weapons-grade anthrax. However, anthrax was not the only agent produced at SNOPB. The facility also produced *Staphylococcus* toxin, Marburg viral vaccines, diagnostic tools, herbicides, and medicines.

The SNOPB facility was designed to incorporate the latest developments in biotechnology. Its construction was aided by access to an abundant amount of power, heat-generating facilities, and skilled construction specialists. When finally constructed, the facility consisted of twenty-five buildings

The facility was connected by a series of pipes to ease the production and transportation of biological agents. Building 211, which produced nutrient media, was connected by pipes to building 221, the production plant. Cultures were placed in fermenters. Selected strains of biological agents were then collected and taken to a Biosafety Level 3 laboratory in building 221. The laboratory contained all of the necessary equipment to cultivate the biological agents, including submarine doors. Cultivation took place in small fermenters, which used gravity to make the selected strain of biological agents descend into larger production fermenters. The solution was then sent to centrifugal separators located on a lower floor. Once the biological agents were separated, they were inserted and sealed into bomblets.

SNOPB, as mentioned previously, specialized in the production of anthrax. After the accidental release of anthrax spores from Sverdlovsk (1979), the West began to suspect that the Soviet Union was building a clandestine biological weapons program. Due to the inherent risks of both human safety and military secrecy, in 1984, the Soviet government began to transfer equipment and personnel from Sverdlovsk to Stepnogorsk.

SNOPB had a 350-person staff in 1984; that number increased to 800 personnel by 1991. The facility was able to attract the most talented Soviet biotechnology scientists, and specialized courses at leading Russian institutions were established for new personnel. SNOPB exchanged technical expertise with Ministry of Defense (MOD) facilities as an equal partner, even though SNOPB was technically subordinate to Biopreparat. The facility had staff from Sverdlovsk and the Kirov MOD research cen-

Andrew Weber led the U.S. effort to rid Kazakhstan of its Soviet-era biological weapon infrastructure. July 2000. (Reuters/Corbis)

ter. Additionally, SNOPB maintained numerous links with important research institutions such as the Institute of Bioorganic Chemistry.

In 1989, SNOPB began to move away from the production of biological agents toward civilian production of vaccines and diagnostic tools. SNOPB worked closely with Progress, and the Soviet authorities decided that SNOPB should now produce human insulin and remove all unnecessary equipment. Following the collapse of the Soviet Union, however, this decision was never implemented.

Today, under a cooperative threat reduction agreement, the United States has supplied funding to dismantle military facilities inside the former Soviet Union related to the production of weapons of mass destruction. Stepnogorsk has been included in an effort to engage the affected facilities personnel in defensive and peaceful scientific work. In 1998, the U.S. Civilian Research and Development Foundation made three project awards that included scientists from the Stepnogorsk facility. Additionally, the U.S. Department of State is providing $210,000 to support projects at the Stepnogorsk facility.

—Robert Wyman

See also: Biopreparat; Russia: Chemical and Biological Weapons Programs; Sverdlovsk Anthrax Accident

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SULFUR MUSTARD

See Mustard (Sulfur and Nitrogen)

SVERDLOVSK ANTHRAX ACCIDENT

The April-May 1979 accidental outbreak of anthrax in Sverdlovsk (now known as Yakaterinberg), Russia provides a telling example of the dangers that are posed by biological weapons programs. In addition to highlighting the nature of the biological agent anthrax and possible distribution methods (i.e., aerosolization), the Sverdlovsk accident also brings to light the ease with which a clandestine biological weapons program can be constructed, operated, and maintained.

Anthrax is an acute infectious disease caused by the spore-forming bacterium *Bacillus anthracis.* Anthrax most commonly occurs in wild and domestic lower vertebrates (cattle, sheep, goats, camels, antelopes, and other herbivores), but it can also occur in humans when they are exposed to infected animals or tissue from infected animals.

Anthrax infection can occur in three forms: cutaneous (skin), inhalation, and gastrointestinal. *B. anthracis* spores can live in the soil for many years, and humans can become infected with anthrax by handling products from infected animals or by inhaling anthrax spores from contaminated animal products. Anthrax can also be spread by eating undercooked meat from infected animals.

Sverdlovsk was home to a secret Soviet government facility known as Compound 19, which manufactured weapons-grade anthrax and other biological agents. Although U.S. intelligence long suspected the existence of the Sverdlovsk biological research facility, it held no corroborating evidence to prove its suspicions that Compound 19 served as a biological weapons facility.

On or about April 2, 1979, millions of anthrax spores escaped from the secret facility. How this happened is still yet to be explained fully by Russian officials. One rumored explanation cites a missing air filter as the culprit for the leak.

Prevailing wind currents carried the escaped spores through a narrow zone extending from the compound all the way to the southernmost part of the city. Those in the immediate path of the spore cloud were at the greatest risk, having been exposed to the highest concentration of spores. As the spore cloud dissipated, its strength began to dwindle. Cattle as far away as 30 miles south of the city, however, were still found dead due to anthrax exposure, a testament to the efficiency with which the agent dispersed.

By all official Soviet accounts, this accidental release of a highly contractible aerosolized strain of anthrax in the working-class city of Sverdlovsk claimed the lives of sixty-four men and women in the spring of 1979. Some reports place the number of fatalities at closer to 100, and some earlier intelligence estimates placed casualty estimates into the thousands.

Immediate word of what happened in Sverdlovsk was scarce, even within the city and surrounding territories. Rumors were rampant of a strange disease that wasted healthy people away in a matter of days. No articles, television reports, or government statements were made, and aside from the random attempts by citizens to sanitize their homes against the invisible danger, there was little in the way of outward appearance which would have indicated any trouble at all. Local medical staff were only informed of the possibility of an outbreak "of some kind" and were given no further advice or support.

Initial U.S. intelligence reports regarding the outbreak relied upon second- and third- hand word of mouth. Word of the outbreak did not reach Western media sources until early 1980. As word of the outbreak finally began to surface in the West, the Soviet government hatched an outbreak scenario to explain the incident while protecting Compound 19's existence.

To conceal the true nature of the outbreak, Soviet officials first attributed the disease to the consumption of contaminated meat. Articles began to appear in Soviet medical, veterinary, and legal journals reporting on an anthrax outbreak that occurred in Sverdlovsk-area cattle. These articles implicated the consumption of this contaminated meat as the cause of the outbreak of the disease in the local community. Russian officials even went as far as to state that the reason why the majority of victims were middle-aged males was that males, as the typically dominant meat consumers in a working-class town such as Sverdlovsk, were far more likely to come into contact with contaminated meat.

U.S. agencies, however, citing epidemiological evidence showing a clear pattern of infection synonymous with inhalatory anthrax, concluded that the agent was aerosolized and most likely linked to the suspected Sverdlovsk biological research facility.

The source of the outbreak became a matter of intense international debate: Authorities knew that if the outbreak were proven to be of other than natural origin, it would be evidence of actions prohibited by the 1972 Biological and Toxin Weapons

Convention. In 1986, after a number of previous efforts had failed, a team of independent investigators was sent to Moscow for discussions with the four primary physicians directly responsible for dealing with the outbreak. Two years later, two of the primary physicians were invited back to the United States, where they provided formal presentations outlining the official Soviet stance on what occurred.

Although U.S. officials agreed that the evidence provided suggested the possibility of a gastrointestinal anthrax outbreak, they concluded that they required additional forensic evidence to reach a definitive conclusion about the origins of the disease.

In 1990, several articles about the epidemic surfaced that questioned the original Soviet explanation of the outbreak. As pressure mounted on the new post-Communist Russian government, President Boris Yeltsin (who, in 1979, was the chief Communist Party official for the Sverdlovsk area), directed his Counselor for Ecology and Health to determine the origin of the epidemic. In May 1992, Yeltsin was quoted as stating: “the KGB admitted that our military developments were the cause.” The Russian government has provided no further information regarding the outbreak. Subsequently, the chairman of the committee to oversee biological and chemical disarmament expressed doubt that the biological agent originated at Compound 19. The committee then conducted its own investigation into the outbreak, but has yet to provide the results of its investigation.

—*Brian L'Italien*

See also: Aerosol; Anthrax; Russia: Chemical and Biological Weapons Programs

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SYRIA: CHEMICAL AND BIOLOGICAL WEAPONS PROGRAMS

Although constrained by limited resources, Syria reportedly possesses an active chemical warfare program and a limited biological warfare program. Syria has also acquired a substantial force of ballistic missiles capable of delivering chemical munitions to targets throughout Israel. Syria views Israel as its primary external threat and sees its chemical weapons, and possibly its less advanced biological warfare capabilities, as a means to counter Israel's qualitative military superiority.

Syria's initial interest in chemical and biological weapons probably dates back to the 1970s, when it reportedly received chemical warfare technology and materials, including chemical agents, from Egypt in preparation for the 1973 October War against Israel. With the demise of the Soviet Union, Damascus has placed even greater emphasis on the development and acquisition of unconventional weapons to make up for the loss of Soviet conventional military support and for Syria's growing military asymmetry with Israel.

Chemical Weapons

Syria has not acceded to the Chemical Weapons Convention and has had a chemical warfare program for many years, although it has never used chemical agents in a conflict. According to a 2001 U.S. Department of Defense report, “Damascus already has a stockpile of the nerve agent sarin that can be delivered by aircraft or ballistic missiles. Additionally, Syria is trying to develop the more toxic and persistent nerve agent VX. In the future, Syria can be expected to continue to improve its chemical agent production and storage infrastructure. Damascus remains dependent on foreign sources for key elements of its chemical warfare program, including precursor chemicals and key production equipment. For example, during 1999, Syria sought chemical warfare-related precursors and expertise from foreign sources” (U.S. Department of Defense, 2001, p. 45). Media sources—including the Arabic newspaper *Al Hayat* (London) and *Washington Times,* among others—have reported that Damascus has received direct assistance from Russia (and formerly the Soviet Union), Iran, and North Korea in developing its CBW and missile programs.

The U.S. Central Intelligence Agency confirmed that in 2003 Syria continued to seek CW-related expertise from foreign sources: “Damascus already held a stockpile of the nerve agent sarin, but apparently tried to develop more toxic and persistent nerve agents. Syria remained dependent on foreign sources for key elements of its CW program, including precursor chemicals and key production equipment" (CIA, p. 6). Syria's motivation to acquire chemical warfare agents and ballistic missiles appears to be a response to Israel's superior conventional military capabilities. Insufficient public information exists to determine whether Syria plans to use CW primarily on the battlefield or if this capability is reserved for employment as a counterforce deterrent against potential Israeli attack.

Biological Weapons

Syria signed the Biological and Toxin Weapons Convention in April 1972, but since that time it has refused to ratify the treaty and has given no indication that it might do so in the near future. Although there is very little hard evidence in the public domain, both government and media sources (e.g., *New York Times* and *Jane's Defence Weekly*) suggest that Damascus is pursuing the development of biological weapons. Israeli sources (such as Dany Shoham) have asserted that Syria possesses *Bacillus anthracis* (which causes anthrax), botulinum toxin, and ricin. Other independent assessments (such as those published by the Nuclear Threat Initiative), however, maintain that there is no evidence that the country has progressed past the research and development phase of a BW capability. Syria has a pharmaceutical infrastructure that could support a limited BW program, and it engages in extensive trade of dual-use equipment and goods with companies in western Europe, Russia, and North Korea.

According to the 2001 U.S. Defense Department document, *Proliferation: Threat and Response,* "Syria's biotechnical infrastructure is capable of supporting limited agent development. However, the Syrians are not believed to have begun any major effort to put biological agents into weapons. Without significant foreign assistance, it is unlikely that Syria could manufacture significant amounts of biological weapons for several years" (p. 45). In a more recent assessment, however, the CIA reported in 2003: "it is highly probable that Syria also continued to develop an offensive BW capability" (CIA, p. 6).

Ballistic Missiles

As mentioned above, Syria's missile program began in the early 1970s as a means to counter Israel's superior military capabilities. Because Syrian defense planners have no illusion about the effectiveness of their own air force against Israel's air defense network, Damascus has made its missile development program a top priority. Today, Syria's arsenal of ballistic missiles, consisting of hundreds of Scud-derived missile systems, is one of the largest in the Middle East. Syria is believed to have chemical-filled warheads available for a portion of its Scud missile force.

In the 1970s and 1980s, the Soviet Union provided Syria with technology and support for its missile program and transferred to Damascus the Soviet FROG-7, Scud-Bs, and the solid-fueled Scarab SS-21 missile systems. In the 1990s, Syria looked to other states to supply it with missile technology and found willing partners in Iran and North Korea. Iran provided Syria with technical assistance for solid-fueled rocket motor production, and North Korea supplied it with equipment and technical assistance for liquid-fueled missile production. Syria, however, has had difficulty creating an indigenous production capability and has had to rely on continued imports from countries such as North Korea, China, and Russia. Syria reportedly purchased 150 Scud-C missiles from North Korea in 1991. In September 2000, Syria tested a North Korean 700-kilometer-range Scud-D missile, revealing its continued commitment to expanding its missile capability. All of Syria's missiles are mobile, that is, are transportable on vehicles, and can reach much of Israel and large portions of Iraq, Jordan, and Turkey from launch sites well within Syria.

In addition to its ballistic missiles, Syria has a variety of Soviet-made land- and sea-launched short-range antiship cruise missiles and air-launched short-range tactical missiles, which have the potential to deliver chemical and biological weapons. Syria also has numerous fighter aircraft, helicopters, artillery, and rockets available.

—Peter Lavoy

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TABUN

The first of the G-series ("G" for German) nerve agents, tabun was discovered in 1936 by Gerhard Schräder and his colleagues at the German firm I. G. Farben while conducting some agricultural research on pesticides. Shortly thereafter, Germany undertook efforts to produce large quantities of tabun, but due to various logistical and technical hurdles, production did not begin until 1942. Tabun was intended to be disseminated as a deadly aerosol by the German military, but despite their having produced 12,000 pounds of tabun, the agent was never used. Half a century later, Iraq declared that it had developed about 210 tons of tabun, most of which was believed to be of poor quality. Thirty tons of Iraqi tabun were destroyed by the UN Special Commission (UNSCOM) in the 1990s, while the remainder is still unaccounted for.

Tabun is a cyanide-containing organophosphate that is much less volatile than other G-series agents. It is only slightly soluble in water but can dissolve more easily in fat-soluble solvents. Tabun can be stored (in steel containers) up to several years at ordinary temperatures. Described as having a slightly "fruity" smell, pure tabun is actually an odorless, brownish liquid.

Tabun production is quite simple, requiring only four primary precursors: sodium cyanide, dimethylamine, phosphorus oxychloride, and ethyl alcohol. Its relative ease of production was probably the reason Iraqi scientists chose to manufacture tabun as a significant part of the country's chemical weapons program. Like other nerve agents, tabun prevents the enzyme acetylcholinesterase (AChE) from hydrolyzing (breaking apart with water molecules) acetylcholine (an essential neurotransmitter), eventually leading to nervous system failure. Initial symptoms of exposure include breathing difficulty, nausea, headache, drowsiness, twitching, and loss of muscle control. Depending on the lethality of the agent and the mode of delivery, tabun can kill a human being within 15 minutes to a few hours.

—Anjali Bhattacharjee

See also: G-Series Nerve Agents; Nerve Agents; Organophosphates

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TERRORISM WITH CBRN WEAPONS

Terrorist use of chemical, biological, radiological, and nuclear (CBRN) weapons and devices is considered the most likely form of future "unconventional" warfare. In this next phase of "asymmetrical" warfare, terrorist operatives will exploit the latest technological advances, albeit through relatively crude or unsophisticated means, to inflict catastrophic harm against much more powerful adversaries. This forecast is not intended to imply that conventional terrorist warfare will not remain the most pervasive form of warfare facing the world—and that it will not become increasingly lethal and

Firefighters practice decontamination measures in a WMD terrorism exercise. Cambridge, MA, May 2004. (Jim Bourg/Reuters/Corbis)

damaging in its own right—but that as terrorist groups, especially the al-Qaeda network, escalate the lethality of their warfare, CBRN weapons (i.e., in terms of agents, devices, and delivery systems) are likely to play a larger role among terrorists' weapons of choice.

The world already confronts the specter of CBRN terrorism. With regard to biological weapons, in late January 2003, al-Qaeda operatives arrested in Great Britain and in Spain were suspected of plotting biological attacks using the deadly toxin ricin against a major European city. Al-Qaeda's British cell had reportedly plotted to employ ricin to lace the food supply at a British military base. Following al-Qaeda's simultaneous suicide aircraft attacks of September 11, 2001, which represented the most catastrophic terrorist operations to date but which still employed conventional means, an unknown perpetrator launched a poisonous anthrax letter campaign that killed five persons and terrorized the entire United States. The anthrax attacks represented the second largest biological terrorist operation in the United States. In 1984, the Bagwan Rajneeshee cult carried out a *Salmonella* food poisoning of the salad bars of several Oregon restaurants, which fortunately did not lead to any deaths, but made at least 750 people ill.

In terms of chemical weapons, in February 2002, a plot by an al-Qaeda cell to poison Rome's water supply with cyanide-based chemicals was thwarted by Italian authorities. (It is likely that this apparent plan would not have succeeded, as the chemical chose, ferrocyanide, has a very low toxicity profile.) This was followed in August 2002 with the CNN television network running a series of reports on captured al-Qaeda documents and training films that demonstrated the magnitude of al-Qaeda's interest and training in employing chemical weapons. Al-Qaeda's intention to carry out CW attacks was further confirmed in November 2002, when British police arrested three al-Qaeda operatives who had plotted to release cyanide gas on the London Underground.

The first major international chemical operation by a terrorist group was the March 1995 sarin nerve agent attack by the Japanese cult Aum Shinrikyo on the Tokyo subway system, killing 12 people and wounding 3,796 others. The group's first major sarin attack occurred in 1994 against the Japanese town of Matsumoto. According to testimony by Dr. Ikuo Hayashi, a cult member, the group had also plotted to release nerve gas in the United States in 1994, but the plan was never carried out.

Palestinian terrorist groups have also exhibited some interest in acquiring a CBW capability. According to the Israeli media, members of Hamas's military wing have been collecting information to carry out CBW attacks. In 2002, Israeli security forces arrested members of a Hamas cell who admitted that the group was gearing up for attacks involving unconventional weapons. In late 2002, Israel's media also reported a Hamas plan to poison the food supply in a Jerusalem restaurant. In January of 2003, Walid al-Ara, an owner of a computer store in Gaza and a member of Hamas's military wing, was indicted for allegedly researching the subject of BW on the Internet on behalf of a top Hamas operative. Israel claims that evidence of Hamas's interest in biological weapons has also been discovered in one of the group's explosives laboratories in the West Bank. Another group, Palestinian Islamic Jihad, had reportedly planned to poison the water supply of a Jerusalem hospital. Israel's media also carried a story claiming that a Palestinian al-Qaeda operative had planned to poison the entire country's water supply.

There are also precedents for concern about terrorists' use of radiological dirty bombs. In 2001, for example, Russian authorities uncovered a container filled with 2 kilograms of a "radioactive substance" in Shali, Chechnya. In May 2002, Jose Padilla, an al-Qaeda operative, was arrested at Chicago's O'Hare International Airport and charged with plotting to detonate a radiological dirty bomb in the United States.

Although there are no precedents for nuclear terrorism, in November 2002, a Tunisian man with links to al-Qaeda, who had been arrested in Belgium the previous year, claimed that he was part of a plot to attack an air base in that country where U.S. nuclear bombs were stored.

As indicated by these plots and thwarted operations, the al-Qaeda terrorist network, with its worldwide logistical reach, is considered the most likely terrorist candidate to employ CBRN weapons against the United States and its allies.

Whether actually executed, thwarted, or nascent plots, these efforts by terrorist groups have cumulatively crossed the threshold from conventional to CBRN terrorism, about which terrorism experts have been warning with increasing frequency since the mid-1990s. As a result, the U.S. government, as well as its allies, has been expending several billion dollars annually in homeland security-related protective training, technologies, new organizational structures, and preemptive strategies.

A New Terrorist Paradigm

The specter of CBRN terrorism (and the conventional catastrophic terrorism of September 11) has transformed the previous paradigm about the magnitude of terrorist warfare. Thus, the famous maxim formulated by Brian Jenkins of the RAND Corporation, a public policy think tank, that "terrorists want a lot of people watching, not a lot of people dead," has been replaced by the dictum that, today, "terrorists want a lot of people watching, *and* a lot of people dead."

The breaking of the previous taboo by terrorist groups against mass casualty attacks has ushered in a new era of catastrophic terrorist warfare in which CBRN are likely components in the terrorists' modus operandi and weapons arsenal.

Despite the presumed imminence of terrorist use of CBRN, the majority of today's terrorist incidents still involve conventional weapons and devices. Conventional devices still remain the terrorists' weapons of choice, although they have evolved into highly lethal weapons. For example, although suicide bombings have become the tactic of choice for today's most lethal groups, replacing the previous modus operandi of "attack and escape," their explosives belts are still conventional in nature. The concern, however, is that in the future the weapons in these explosives belts will be laced with various poisons that will infect and kill a much larger circle of victims than conventional explosives will affect.

Because the transition from conventional to unconventional terrorist warfare is still largely incomplete, a comprehensive threat assessment is required to forecast whether or not a terrorist group is likely to embark on conventional or unconventional warfare. In assessing the likelihood of CBRN terrorist warfare, six questions need to be answered. Within these questions are a multiplicity of accelerators and triggers, and internal and external hurdles that need to be overcome for a group to mount a CBRN terrorist operation.

Assessing the Likelihood of CBRN Terrorism: Six Questions

First, what acquisition costs would influence a terrorist group to acquire the capability to employ CBRN weapons and devices? In terms of the financial considerations involved in acquiring CBRN weapons, devices, and delivery systems, significant financial resources are required for terrorist groups to be able to develop an indigenous CBRN operational capability unless a group succeeds in obtaining such a device from a state sponsor or in stealing or hijacking such a device. In general, a range of costs are involved in acquiring, weaponizing, stockpiling, and deploying CBRN weapons of varying levels of sophistication and lethality. As a result, financial considerations play a role in deciding whether a group will choose single or multiple CBRN weapons, what types of dispersal systems they will use, and whether these weapons will be indigenously developed, obtained from an external source (whether legally or through smuggling, hijacking, or theft), or provided by a state sponsor.

CBRN weapons for use in terrorist attacks vary greatly in their cost. For example, acquiring, or producing and developing, an operational capability to deploy chemical or biological weapons and devices involves relatively small financial resources and is within the means of many terrorist groups. Far more significant financial resources, which only a few groups possess, are necessary to acquire tactical nuclear weapons, such as suitcase nuclear devices. Nevertheless, some terrorist groups, such as Aum Shinrikyo in its heyday, the al-Qaeda network, or Colombian narcotics traffickers, could potentially acquire a crude nuclear weapon because of the vast financial resources accruing from their multiplicity of legitimate and criminal business enterprises.

The second question concerns the goals of a group in acquiring CBRN weapons and what they hope to achieve in their use. Thus, in terms of biological weapons, a group might choose to employ agents and toxins that can cause mass destruction, such as the highly contagious smallpox biological agent, which has the potential to kill tens of thousands of victims across a wide geographical region. Some biological attacks may not inflict massive casualties but may instead cause massive economic costs. For example, in the case of the anthrax letter attacks, although there were few deaths as a result, the economic toll was significant, including several hundred million dollars in cleanup costs, the forced relocation of U.S. Senate offices, an overhaul of U.S. postal security, and the closure of the Brentwood postal facility. Chemical weapons such as sarin nerve gas can kill tens or hundreds of victims yet remain contained geographically. The contamination effects of radiological dispersal devices are likely to far outweigh their direct physical impact in an explosion. Thus, even after decontamination, people would be reluctant to return to the previously affected areas, and property values would be depressed for lengthy periods if the neighborhoods were perceived as being radioactive. Nuclear weapons, however crude or miniaturized, would inflict tens of thousands of deaths and widespread radioactive contamination on the affected areas.

Another important consideration for terrorists is whether the chosen CBRN weapons would cause immediate medical health effects vs. delayed effects, short-term vs. long-term effects, mass casualties vs. death, or contamination of areas resulting in short- vs. long-term economic damages.

Third, how technologically feasible is it for a terrorist group to deploy CBRN weapons and devices? In this sphere, the specialized training of members and/or recruitment of individuals with CBRN-related skills is one of the most crucial indicators demonstrating that a group is embarking on CBRN warfare.

Fourth, would such weapons and devices be indigenously developed, acquired in the black or "gray" markets, or provided by a state sponsor? State sponsors provide terrorists with funds, arms, training, documentation, and other types of operational support; obtaining the sponsorship of a state with CBRN resources is a major indicator that a terrorist organization is attempting to carry out catastrophic warfare. There are a number of motivations and strategic and bureaucratic considerations involved in the relationship between terrorist groups and potential state sponsors regarding possible cooperation in catastrophic warfare. An important indicator for cooperation is whether a potential state sponsor is undergoing a profound crisis that would drive it to subcontract a catastrophic operation to a terrorist group.

However, obtaining the support of a state sponsor is not automatic or inevitable. Potential state sponsors would have to weigh the costs and benefits involved in sponsoring CBRN operations by terrorist groups, including providing assistance in the phases of research, development, production, and operations planning. Other issues concern the conditions and arrangements for providing the terrorist group with CBRN weapons, devices, and delivery systems, as well as training, logistics, diplomatic cover, and deniability.

Thus, a number of cost/benefit factors are involved in the relations between state sponsors and surrogate terrorist groups. For both, there are advantages and disadvantages. For terrorist groups, state sponsorship can provide the crucial assistance they require to launch a catastrophic attack. For example, attaining the support of a state sponsor with nuclear capability (such as Iran, Iraq, Pakistan, or North Korea) would shortcut the process of fabricating a high-grade nuclear bomb with weapons-grade material. The latter is an undertaking that would be extremely difficult, although not impossible, for most terrorist groups to successfully complete without assistance. Such a nuclear weapon, however, would likely be smaller in terms of its explosive yield (in kilotons) versus strategic nuclear weapons (megatons).

Fifth, given the technological feasibility of a group's employing CBRN weapons and devices, what human or physical targets (e.g., "trophy" buildings and landmarks, or a critical economic sector, such as agriculture), would these weapons be used against? Would they be employed indoors or outdoors, or against civilian or military targets? In the case of radiological or nuclear warfare, what types of targets would such weapons be employed against, or would conventional means be used to target nuclear power plants or facilities that store radiological devices, thereby inflicting a Chernobyl-type radiological event on the nearby population?

Sixth, what ideological or religious motivations and strategic objectives would drive a terrorist group to employ CBRN, especially given the risk that the use of unconventional weapons could generate an especially massive response from a targeted state? A group that demonstrates a willingness to take high risks in its warfare might be attracted to these types of attacks. Organizations intent on completely destroying a government might also consider a mass casualty event as something that would further their cause. According to terrorism expert Bruce Hoffman, religious groups are the most likely candidates to carry out CBRN terrorism because they are at once activists and constituents engaged in what they see as a total war. Moreover, their terrorist acts are executed for their own audience or constituency, not to influence the behavior of outsiders and nonbelievers. Thus, the restraints that may exist on catastrophic violence by "secular" terrorists—such as political or ethnic identity-based separatism—are not necessarily relevant to religious terrorists.

How likely would it be for terrorist groups to launch a successful CBRN attack? A group would have to attain proficiency in developing and deploying such weapons, but terrorists' probable inexperience in many of the technical tasks involved in CBRN use would make them continuously liable to make mistakes. In the technical realm, for example, untrained people may have difficulty integrating biological agents with munitions or disseminating agents against open-air targets. They may experience numerous testing failures, their facilities may catch fire, or there might be accidental leaks in their facilities. In terms of personnel, counterterrorism and intelligence agencies may succeed in influencing some of their operatives to defect, leading to exposure of a group's CBRN program. Moreover, a group's attempts to recruit foreign technical and warfare specialists may fail or may be reported to intelligence and law enforcement authorities. As a result of the clandestine nature of their operations and of constant surveillance of their activities by government agents, their group might be overcome by internal paranoia, causing them to embark on hasty actions and make mistakes.

—Joshua Sinai

See also: Al-Qaeda; Aum Shinrikyo; Bioterrorism; Sabotage

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THICKENERS

Used in chemical warfare (CW) agent preparations, thickeners increase the persistence—that is, their ability to remain potent in certain environments—of toxic chemicals in warfare. As with napalm—which is essentially a liquid incendiary (petroleum) made more persistent—some CW agents such as soman, VX, lewisite, and mustard have been thickened with several different compounds. By increasing the viscosity of a given CW agent, thickeners increase droplet size during delivery, increasing the amount of contamination reaching the target. Although CW agents such as VX are already highly persistent, Soviet scientists thickened soman and V-agent used to fill their munitions with polymer thickeners.

The medical consequences of exposure to thickened CW agents can be severe and highly complex. Dr. Charles G. Hurst, former commander of the U.S. Medical Research Institute of Chemical Defense, has warned: "Casualties with thickened nerve agents in wounds (e.g., from pieces of contaminated battle dress uniform or protective garment being carried into the wound tract) are unlikely to survive to reach surgery. Thickened mustard has delayed systemic toxicity and can persist in wounds even when large fragments have been removed" (Hurst, p. 356). For current chemical demilitarization programs under way, thickeners have also presented different problems. For example, the use of thickeners by the Soviet Union in its V-gas stockpile has complicated the neutralization process, requiring an additional solvent to to break the polymer matrix.

—Eric A. Croddy

See also: Chemical and Biological Munitions and Military Operations

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TNT

TNT is the acronym for the high explosive trinitrotoluene, one of the most important military explosives. Other names include trotyl, tolite, triton, tritol, and trilite. The chemist Joseph Wilbrand first synthesized the compound in 1863, and large-scale production of TNT began in Germany in 1891. Although TNT was significant in its military applications during World War I, production quantities were limited at the time due to a shortage of one of the critical precursors, toluene, which was only found in coal tar derivatives. However, when petroleum and synthetic processes were developed before World War II, the supply of toluene could be nearly limitless, raising the U.S. production capacity of TNT, for example, from 350,000 tons to 1.8 million tons per year during the 1940s.

Terrorists have been known to employ TNT in large casualty attacks. On August 7, 1998, two U.S. embassies in East Africa were targeted by al-Qaeda suicide bombers—one in Nairobi, Kenya, and the other in Dar es Salaam, Tanzania—driving trucks carrying approximately 2,000 pounds of TNT. At Nairobi, 213 were killed including a dozen Americans, with over 4,500 injured, while 11 people and 85 were injured minutes later at Dar es Salaam. As in the Oklahoma City bombing in 1995, and although conventional explosives were used, the scale of murder and devastation rises to the level of a weapon of mass destruction. The large market for high explosives, especially in areas of construction and engineering, ensures that a large supply of TNT will be available for diversion for use by terrorists or criminals.

—Eric A. Croddy

See also: Al-Qaeda; Oklahoma City Bombing

TOBACCO MOSAIC VIRUS

Tobacco mosaic virus (TMV) is a plant virus infecting tobacco plants and other vegetable plants such as beans. TMV attracted scientists' attention in 1930 when it was shown that a crystalline preparation of TMV was infectious. This discovery had a far-reaching effect on concepts regarding viruses in general: it indicated that TMV without a host cell was a benign material but that in the presence of host cells, TMV was infectious. This discovery suggested that viruses—previously considered to be microorganisms like bacteria only too small to see with the microscope—were more like complex proteins (actually, they were proteins making up the nucleic portion of the virus) that showed living activity only when the host organism was infected with the virus.

Many plant bacteria and viruses are considered to be potential biological weapons, but these are mainly targeted to destroy staple crop plants such as rice, wheat, corn, and potatoes. TMV's destructive scope is more limited to beans, tobacco plants, and possibly tomatoes. Therefore, if TMV were used for biological terrorism, it would be aimed toward damaging the agricultural economy rather than the food supply.

—Anthony Tu

See also: Agroterrorism (Agricultural Biological Warfare)

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TOOELE, UTAH

The Deseret Chemical Depot located at Tooele Army Depot in Utah once stored almost 45 percent of the U.S. chemical weapons stocks, the largest percentage by far of any of the original eight storage sites maintained by the United States (the other seven are Anniston Chemical Activity, Alabama; Blue Grass Chemical Activity, Kentucky; Edgewood Chemical Activity, Aberdeen Proving Ground, Maryland; Newport Chemical Activity, Indiana; Pine Bluff Chemical Activity, Arkansas; Pueblo Chemical Depot, Colorado; and Umatilla Chemical Activity, Oregon).

From completion of the Tooele Chemical Agent Disposal Facility in 1996 until 2003, close to half that amount, or 11 million pounds of these chemical agents, was destroyed by the army's baseline incineration process (*see* Demilitarization of Chemical and Biological Agents). Disposal efforts are scheduled to conclude in 2008.

Tooele Army Depot was established in 1942 as an ordnance depot. In 1949, it also assumed command of the Deseret Chemical Depot, maintaining the ordnance depot in the north area of the installation while operating the chemical depot in the southern area. Early efforts to find methods to destroy chemical weapons included the construction of the Chemical Agent Munitions Disposal System at Tooele in 1979. On a pilot-scale, or small-scale, demonstration capacity, this facility was designed to test and evaluate equipment and processes for destroying chemical agents and munitions. From 1981–1986, this system expanded to test and evaluate incineration as well as processes for decontamination of metal parts and containers.

When Congress ordered the destruction of all U.S. chemical agents and munitions in the Defense Authorization Act of 1986, plans were made to begin building on-site destruction facilities at the various storage locations because of the increased risks presented by the transport of chemical weapons. Incineration, as tested at the Tooele Chemical Agent Munitions Disposal System, became the U.S. Army's baseline method of chemical weapons disposal.

Unlike some of the other U.S. chemical weapons storage sites, Deseret Chemical Depot contained not only ton containers of chemical agents in bulk storage, but also millions of various types of munitions, including cartridges, projectiles, land mines, spray tanks, and rockets. Some of these munitions still contain explosive components, but others do not. There are also a variety of chemical agent types stored at Tooele: blister agents such as mustard, and nerve agents such as sarin and VX (*see* Nerve Agents; Vesicants). Munitions are kept in storage igloos buried underground in a secure section of the depot. Destruction of all sarin gas weapons at the depot was completed in March 2002.

The Tooele Chemical Agent Disposal Facility was the first full-scale destruction facility constructed in the continental United States. During the course of operations, there have been minor leaks reported from the facility. However, none of these have resulted in any types of injuries or have required emergency responses.

—Claudine McCarthy

See also: Demilitarization of Chemical and Biological Agents

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TOXINS (NATURAL)

There are many animals, plants, fungi, and bacteria that contain different types of toxins or that release toxic substances. The term *toxin* is used widely, yet its definition is ambiguous. In many contexts, all toxic substances are called toxins regardless of whether they are naturally occurring substances or human-made ones.

Table T-1: Toxins Ranked According to Toxicity

Natural Toxins	*Origin*
Botulinum Toxin D	Bacteria
Palytoxin	Coral
Tetrodotoxin	Puffer Fishes
Human-Made Toxins	
Hydrogen Cyanide	Inorganic Compound
Carbon Tetrachloride	Inorganic Compound

Some animals possess special ducts or organs that release toxic substances called venoms. Plants do not release toxic substances as such; instead, toxic substances are present within a particular part of the plant. In this case, toxic substances are called toxins.

Natural toxins can be grouped as protein or nonprotein toxins. This is a convenient way to classify toxins because the two types of compounds have distinct properties. Toxins are also grouped into high molecular weight and low molecular weight classes. The high molecular weight toxins are usually proteins, and low molecular weight toxins are usually nonproteins. There are also many toxins whose molecular weights are intermediate in size.

Of all the ways toxins are classified, classification based on biological activity may be the most important. Toxins are classified as neurotoxins, necrotic toxins, cardiotoxins, cytotoxins, nephrotoxins, and hemorrhagic toxins. Of these, the neurotoxins are the most germane to potential use in WMD, and have been most often researched as potential toxin weapons in biological warfare.

Neurotoxins

For neurotoxins, the functional area of the toxin itself and the site of action on the body can be different for each toxin. There are two types of neurotoxins: central neurotoxins (affecting the central nervous system), and peripheral neurotoxins (affecting the peripheral nerves). Apamin, for example, is a bee venom component with twenty-two amino acid residues. It is a central neurotoxin. Morphine and codeine, isolated from poppy seeds, are also central neurotoxins. There are also many different varieties of peripheral toxins affecting various parts of the peripheral nerves. Usually, small-size toxins can be central neurotoxins because they can penetrate the brain-blood barrier, the membrane that prevents most large molecules from entering the neural tissues.

Snake neurotoxins contain presynaptic, postsynaptic, and other types of neurotoxins. They all affect the neuromuscular junction. A presynaptic neurotoxin causes spontaneous release of the neurotransmitter acetylcholine. The result is a spasm of the muscle. After all acetylcholine molecules are released from the vesicle at the nerve ending, however, muscle paralysis eventually occurs. Presynaptic toxins are found in krait (genus *Bungarus*) venom, mamba (genus *Dendroaspis*) venom, and all Australian snake venoms (genus *Notechis, Pseudechis, Austrelaps*).

Postsynaptic toxins are common in snake venoms such as those of the cobra (*Naja*) and sea snake (family Hydrophiidae). At the muscle site of the neuromuscular junction, there is a special acetylcholine receptor. Normally, the receptor accepts acetylcholine, transmitting the nerve signal to the muscle, enabling the muscle to contract. Snake postsynaptic toxins attach to the receptor at the same site where acetylcholine attaches, thereby blocking the receptor. The result is paralysis of the muscle. When the muscles at the end of the diaphragm succumb to this postsynaptic neurotoxin action, the diaphragm stops moving, which can cause respiratory arrest and death.

Botulinum toxins (BT) are the most toxic substances in the world. It is estimated that 1 microgram of the toxin can kill 20 million mice. Botulinum toxin, which comes from the *Clostridium botulinum* bacterium, is a presynaptic toxin that causes muscle paralysis by stopping the release of acetylcholine from the nerve ending.

Natural toxins are potential biological weapons because of their extremely high toxicity. Some toxins are attractive candidates for biological weapons because they can form a stable aerosol, poisoning the body through the lung by inhalation. Usually, pneumonic route poisoning is much more severe than poisoning from oral or dermal routes of entry.

—Anthony Tu and Eric A. Croddy

See also: Botulism (Botuliuum Toxin); Conotoxin; Ricin; Staphylococcal Enterotoxin B; Toxoids and Antitoxins

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TOXOIDS AND ANTITOXINS

As a prophylactic against infectious disease, toxoids are toxins that have been rendered harmless, usually by chemical treatment, and then administered to cause the body to produce antibodies to protect against future infection. In addition to their role in reducing the incidence of childhood diseases, toxoids have been developed for use against biological warfare (BW) agents, especially against botulinum toxin. Passive antitoxins—that is, toxin-specific antibodies utilized to treat diseases such as botulism—are being developed in the United States and elsewhere to respond to a bioterrorism incident.

How toxoids are administered depends upon the nature and process of the infectious disease being combated. Toxoids are usually administered to combat bacteria that produce toxins. Examples of these are classic childhood illnesses such as whooping cough (*Bordetella pertussis*), diphtheria (*Corynebacterium diphtheriae*), and tetanus (*Clostridium tetani*). Thus, it has become standard practice to vaccinate against diphtheria, pertussis, and tetanus (DPT) by using their respective toxoids or in combination with other vaccine techniques. Toxoids were also produced during World War II against a relatively new threat—the specter of BW—when early intelligence indicated that Nazi Germany was planning an attack using botulinum toxin.

Development during War and Peace

If disease has influenced the course of peoples, civilization, and warfare, then it has often been the exigencies of war that determined the course of modern vaccine development. Despite the scientific advancements in the nineteenth century that promised to lower childhood mortality from disease, it was military demands that drove those advancements' early applications.

Although not all early vaccines were successful (some, in fact, did more harm than good), by 1914, effective and safe vaccines were available for smallpox (vaccinia), rabies, anthrax, and whooping cough (*pertussis* toxoid). The use of tetanus antitoxin saved countless lives during World War I: Tetanus, along with gas gangrene (caused by the toxin-producing bacterium *Clostridium perfringens*), was especially common as an illness acquired from battlefield injuries.

Toxoids were produced during World War II to defend against a possible BW attack by Germany. Allied intelligence indicated that Germany was planning to use botulinum toxin against the troops ready to land on Normandy's beaches in 1944. Although the details were sketchy, botulinum toxin was notorious for being highly lethal in extremely small quantities. (Produced by the bacterium *Clostridium botulinum,* the toxin produces a flaccid paralysis in the body. Ingested amounts of botulinum as small as 1 microgram are deadly in humans.) This intelligence information led to a rush production of botulinum toxoid for the troops gathering in England. As the official history of the U.S. BW program in World War II notes, however, the British had no toxoids available, but the American and Canadian troops were well supplied. In the end, none of the troops were inoculated against botulinum toxin, the British having decided (based on decrypts of German communications) that the original intelligence was faulty. U.S. officials followed the British lead and came to doubt that botulinum toxin would be an effective agent for aerial dissemination.

During the Gulf War (1990–1991), some 8,000 U.S. troops were administered the botulinum toxoid out of fear that Iraq would use its biological weapons. This turned out to be an unnecessary (albeit prudent) measure.

Currently, the United States has in its inventory a botulinum toxoid that protects against A through E types, and a botulinum antitoxin derived from horse sera under Investigational New Drug (IND) status (2003). The antitoxin is produced by generating antibodies to botulinum toxin in a live horse. This is accomplished by administering small doses of botulinum toxin to the horse, and these antibodies are separated from the horse blood products. These antibodies are then treated with enzymes that remove the "horse" component, so that the active portion of the antibody should be safer to use in humans.

Another toxin that is considered a significant threat in BW or bioterrorism is ricin, a highly poisonous lectin, a protein-containing substance derived from the castor bean. Not nearly as toxic as botulinum, ricin is nevertheless relatively easy to produce from commercially available materials. Research in the United States is underway to develop prophylaxis for ricin, and an IND toxoid is under evaluation. Although ricin is not suspected to form a significant threat in a military context, it is known that al-Qaeda operatives are interested—and have received rudimentary training—in the production of ricin toxin in makeshift laboratories. Ricin's potential use as a terror weapon was confirmed when it was discovered in powder form in some envelopes sent to U.S. Senate offices in February 2004.

Staphylococcal enterotoxin B (SEB), produced by the bacterium *Staphylococcus aureus,* is a highly potent toxin that was weaponized by the United States during the Cold War. The toxin could pose a threat from bioterrorists interested in sabotaging food or beverages, and its aerosolization is another possible route of attack. A formalin-treated (toxin is rendered harmless by adding formaldehyde) SEB toxoid has demonstrated some degree of efficacy in animal trials but has not yet been approved for human use.

Numerous toxoids and antitoxins have been developed for clinical use against snake venom, conotoxins (Pacific cone snails), and other poisonous substances produced in living organisms. Some countries, such as Australia, have sophisticated public health responses to naturally caused incidences of poisoning by these toxins. The BW threat posed by these toxins, however, is probably low.

—Eric A. Croddy

See also: Bioterrorism; Vaccines

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TULAREMIA

Tularemia is an infectious disease of small mammals caused by the bacterium *Francisella tularensis.* Humans usually acquire *F. tularensis* from the bite of an infected insect or from contact with infected wild animals. Less often, tularemia results from inhalation or ingestion of contaminated dusts, food, or water. The onset of tularemia in humans is usually 3–5 days following exposure, and the disease usually begins with fever and flulike symptoms, including headache, chills, fever, and cough. Multiple tularemia syndromes can occur, including pneumonia and "typhoidal" tularemia (an infection throughout the body), which can be fatal. About 75 percent of all tularemia cases present with skin lesions and swollen lymph nodes (ulceroglandular), and 4 percent of these patients die without treatment. The remaining 25 percent, typhoidal, has a mortality rate of about 35 percent without treatment. With the use of antibiotics, the disease (encompassing both syndromes) has a death rate between 1 and 2.5 percent.

The organism is dangerous because it can be released as an aerosol to cause large tularemia epidemics in both human and animal populations at the same time. *F. tularensis* is extremely infectious in humans, requiring inhalation of only ten to fifty organisms to cause severe, incapacitating, and sometimes fatal results. Tularemia can also infect a wide variety of small aquatic and terrestrial mammals, insects, birds, fish, amphibians, amoeba, and other invertebrates, which then act as carriers for the disease. Generally, the organism is hardy and is tolerant of cold temperatures, and it persists in the environment in water, moist soil, hay, straw, and decaying animal carcasses. A World Health Organization committee estimated in 1970 that if 50 kilograms (110 pounds) of a virulent strain of the bacterium were sprayed over a metropolitan area with a population of 5 million, it could incapacitate 250,000 people and kill 19,000. Respiratory failure or shock would cause most of the fatalities.

Tularemia occurs only in the Northern Hemisphere, with naturally occurring outbreaks being most frequent in Scandinavia, Japan, Russia, and North America. Recently, tularemia was reported in southern European nations including Spain, Switzerland, Turkey, and Kosovo. Dozens of biting and bloodsucking insect vectors, especially ticks and tabanid flies (horse flies and deer flies), can transmit the disease. In Europe, mosquitoes and ticks are particularly important disease vectors. Tularemia is primarily a disease of wild rabbits and rodents (mice, rats, lemmings, voles, squirrels, groundhogs, prairie dogs, and beavers). Other mammals that act as carriers for the disease include opossums, sheep, coyotes, and domestic dogs and cats. Tularemia is spread among animals by predatory feeding, cannibalism, insect vectors, and exposure to mud and water contaminated with animal urine and feces.

In the United States, cases of tularemia have been found in all states except Hawaii. It is most commonly transmitted by tick bites or by contact with infectious tissues of wild rabbits. Direct human-to-human transmission of tularemia does not occur, but indirect transmission from wild rabbits to humans (such as through the bites of pet dogs or cats that have been in contact with diseased rodents) has been reported. Hunters, trappers, fur handlers, taxidermists, game wardens, farmers, forest workers, butchers, wildlife veterinarians, and laboratory workers are the people most commonly infected.

Historical Background

Research on the military use of *F. tularensis* to spread disease began in the 1930s in Japan and Russia. During World War II, the U.S. War Research Service noted the extremely high infectivity of this organism and developed the highly virulent Schu-4 strain for weaponization (U.S. code UL). The Soviet Union acquired the Schu-4 strain in the 1950s (apparently obtained from the United States) for its own biological weapons program. Its extremely high infectivity via inhalation makes *F. tularensis* one of the most potent germ warfare agents. In the U.S. biological warfare (BW) program, tularemia bacteria were freeze-dried and milled to a fine consistency to deliver as an aerosol. A live vaccine, effective antibiotic treatment, and prophylaxis protocols that can prevent the development of significant disease in exposed persons were developed by the United States military during the 1950s and 1960s.

Biological weapon stockpiles, including tularemia bacteria, were destroyed by the United States upon signing the Biological and Toxin Weapons Convention of 1972, when many other countries also agreed to end their state-sponsored offensive biowarfare programs. The Soviet Union, however, continued its biological weapons development well after signing the accord and further increased its range of biological warfare agents. Russia finally acknowledged its program in the early 1990s and admitted that genetically engineered vaccine- and antibiotic-resistant *F. tularensis* strains were still being produced as weapons in the former Soviet Union. As of 2003, however, it is not known whether Russia still maintains an offensive BW program.

Tularemia was first described in Japan in 1837 and in Russia in 1926. The organism, renamed *Francisella tularensis* in 1974, was originally isolated in 1911 from ground squirrels with a plaguelike illness in Tulare County, California. It was not until 1921 that Dr. Edward Francis of the United States Public Health Service established that the bacterium was the cause of deerfly fever. Tularemia is also colloquially known in different parts of the world as rancher's fever, rabbit fever (yatobyo in Japan), hare plague, and lemming fever.

Medical Aspects

The bacterium *F. tularensis* can invade and multiply within host cells and can survive inside cells for long periods. There are two major biotypes of *F. tularensis* found in nature, usually referred to as type A and type B. Many type A strains are highly virulent for humans and are found mainly in rabbits, rodents, and ticks throughout North America, and recently in Europe (1998). Type B strains produce a milder and benign, often unnoticed, infection in humans. Type B strains, common in parts of North America, Europe, and Asia, do not cause disease in rabbits but are usually associated with waterborne disease of rodents and mosquito vectors.

The epidemic potential of tularemia became known in the 1930s when large waterborne outbreaks occurred in Europe. Outbreaks of tularemia in wild animals are often harbingers of outbreaks in humans. In Sweden and the former Soviet Union, human outbreaks of tularemia have been linked to ground vole die-offs. Tularemia is predominantly a rural disease, and large outbreaks occurring in war zones are associated with the breakdown of public health and with surging rat populations that carry the disease. An outbreak of a mild form of the disease in Kosovo in early 2000 was due to an increase in the population of infected rats, which was a result of the breakdown of garbage collection after the war of separation from Yugoslavia.

During World War II, a tularemia epidemic affected many thousands of German and Russian soldiers on the European eastern front at the Battle of Stalingrad in 1941. The possibility that this epidemic may have resulted from intentional dissemination of *F. tularensis* by the Russians against German troops was raised by Ken Alibek, a former senior scientist in the Soviet biowarfare program. A more mundane explanation was later offered, however: Tularemia was already widespread in the local populace of the Volga region well before German armies had made their approach. Meanwhile, fighting had essentially destroyed the local public health infrastructure while also preventing the harvesting of crops. As vermin consumed this uncut grain, the rodent population subsequently exploded, widening the focus of disease. Together, these circumstances cleared the way for an epidemic. Many infections among Russian and German troops occurred from inhaled dust from straw used for bedding.

Tularemia is not a notifiable disease to the World Health Organization, so its worldwide incidence is unknown. The frequency of tularemia in the United States, however, has dropped markedly from thousands of cases reported in the 1930s to several hundred cases reported annually through 1994, when it was removed from the list of notifiable diseases. Only in 1999, with increasing concerns of bioterrorism, was tularemia reinstated as a notifiable disease in the United States.

Reasons given for the apparent rarity of tularemia today include decreased rabbit hunting, and therefore reduced opportunity to come into contact with infectious rabbit tissues, as well as the probability that many infections are undiagnosed, misdiagnosed, or unreported due to the relatively benign nature of the disease in some cases. Also, because many people are presumptively treated with antibiotics, that is, no specific pathogen is identified—and because laboratory testing for tularemia bacteria can be difficult—this disease is much less commonly reported nowadays in North America.

Six clinical tularemia syndromes are recognized, depending largely on the route through which the bacterium enters the body (inoculation, inhalation, or ingestion). Typically, 90–100 percent of those exposed to the bacterium develop disease. All forms usually begin with the sudden onset of flulike symptoms: fever (103° to 104° F), chills, headache, generalized joint and muscle aches, cough, and lethargy. Symptoms usually develop within 3–5 days of presumed exposure to *F. tularensis.* The disease course is influenced by host and bacterial factors, including the virulence of the infecting organism, the amount of bacteria introduced, the route of entry, and the host's immune status.

In the most common form, ulceroglandular tularemia (about 75 percent of recognized cases), the bacterium is acquired through a tick bite. An ulcerative skin lesion is found at the site of inoculation and may persist for several months. In hunters and trappers, the organism usually enters the body through a scratch or microabrasion on the hands while skinning or cleaning an infected wild animal. The bacterium spreads to the local lymph nodes, and onset of flulike symptoms is accompanied by painful swollen lymph nodes resembling the buboes associated with bubonic plague. If the organism enters the bloodstream, it may spread to distant organs (lungs, kidneys, spleen, liver, intestines, central nervous system, and skeletal muscles). Recovery can be protracted (from 3 weeks to several months), but this form of the disease is rarely fatal even without treatment. (A second form of this ulceroglandular syndrome, glandular tularemia, has similar symptoms without the characteristic skin lesion.)

Oculoglandular tularemia (1 to 2 percent of cases) may result if the organism enters the conjunctiva due to splashing or rubbing of the eyes after contact with infectious material. Usually only one eye is affected, with painful ulcers and nodules on the conjunctiva. Without treatment, the infection can spread to the local lymph nodes, developing into the glandular form. Rarely, oropharyngeal or gastrointestinal (GI) tularemia is acquired from drinking contaminated water or eating inadequately cooked rabbit meat. Following this type of infection, the tonsils enlarge and dead tissue may form in the oral and throat cavities (pseudomembrane) resembling that found with diphtheria. Patients usually experience sore throat, abdominal pain, nausea, vomiting, diarrhea, and, occasionally, GI bleeding. Depending on the infecting dose, clinical severity ranges from mild but persistent diarrhea to an acute fatal disease with intestinal ulcerations.

Typhoidal (septicemic) tularemia once accounted for up to 25 percent of tularemia cases worldwide but is now rare in the United States. In most cases, the route of entry is unknown but is most likely the result of inhalation of contaminated environmental dusts or aerosolized bacteria. This form is often associated with a huge inoculum or a preexisting compromising condition; patients with this form of the disease experience severe bacteremic disease, septic shock, and, frequently, atypical pneumonia that can be fatal.

Tularemia pneumonia is uncommon but may result from the inhalation of aerosolized bacteria. It also may spread to the lungs as a complication in 10 to 15 percent of ulceroglandular cases, and in about half the cases of typhoidal tularemia. This form of the disease may occur in laboratory workers. Naturally acquired cases occur occasionally from handling infected birds and animals, as well as from other activities such as mowing grass or handling hay that generates dusts from infected rodent nests. Patients with this form usually complain of dry cough and shortness of breath. If untreated, this form of tularemia could progress to respiratory failure, shock, and death.

The mortality rate for severe untreated infections (including all cases of untreated tularemia pneumonia and typhoidal tularemia) is about 35 percent. In the United States, recent mortality rates have been 1–2.5 percent with treatment. Poor outcomes are often associated with long delays in diagnosis and treatment. Early antibiotic therapy is effective, and if started within 24 hours of exposure, may even prevent disease. A variety of antibiotics have been used with success, including aminoglycosides (streptomycin and gentamicin), macrolides, chloramphenicol, tetracycline, and fluoroquinolones (ciprofloxacin). Lifelong immunity is widely reported to follow recovery from infection with *F. tularensis.* There are cases, however, of reinfection.

Early diagnosis of tularemia is difficult because a patient does not usually seek medical attention for a small skin lesion, and at the onset of disease, the clinical picture is typical of other illnesses. Culture and isolation (careful handling is required) of *F. tularensis* is usually done in reference microbiology laboratories, specially equipped with technology and expertise to make a definite identification. Recovery of the bacterium from a patient's ulcer scrapings, lymph node biopsies, sputum, and, rarely, blood is diagnostic but difficult. *F. tularensis* is fastidious and grows very slowly in culture. The diagnosis of tularemia is usually confirmed by blood testing, and *F. tularensis* antigens may be detected in the blood and urine of patients. An antibody response to *F. tularensis* infection is detectable around 2 to 3 weeks after infection. A fourfold increase in antibody levels at 4 to 6 weeks after infection is considered diagnostic. Molecular tests, such as the polymerase chain reaction (PCR, which can multiply small amounts of genetic material into detectable quantities), have been useful to detect *F. tularensis* DNA.

Vaccines to prevent tularemia were developed and used in humans in the Soviet Union in the 1940s and 1950s. A live, attenuated vaccine using a *F. tularensis* type B strain called Live Vaccine Strain (LVS) is currently available as an Investigational New Drug from the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID). The LVS was demonstrated to protect human volunteers against an aerosol attack with virulent *F. tularensis.* An analysis of laboratory-acquired infections showed that LVS prevents the typhoidal form (inhalational route of infection) of the disease and lessens the severity of ulceroglandular forms (cutaneous) of tularemia. The LVS is recommended for people who work in occupations with a high risk of contracting tularemia.

—*Amy E. Krafft*

See also: Aerosol; Russia: Chemical and Biological Weapons Programs; United States: Chemical and Biological Weapons Programs

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TUBERCULOSIS (TB, MYCOBACTERIUM TUBERCULOSIS)

Tuberculosis (TB) is a bacterial infection caused by the bacterium *Mycobacterium tuberculosis* that can affect many areas of the body, primarily via the lungs, causing fatigue, weight loss, fever, night sweats, chills, chronic cough, and coughing up of blood or sputum. Although tissue samples from 5,400-year-old graves have tested positive for *Mycobacterium tuberculosis,* it was not until 1882 that Robert Koch discovered the tuberculosis-causing bacteria.

The TB bacterium is spread through aerosolized infectious droplets that enter the lungs, multiplying to cause disease locally and then spreading to other parts of the body. With an intact immune system, TB can often be controlled. The bacterium may persist, however, in a latent, noninfectious, asymptomatic form for a lifetime, becoming active upon weakening of the immune system. The disease is particularly serious in the elderly, those who are immunocompromised (especially HIV-infected people), young children, and babies.

Previous military research by the United States and Japan has involved TB mainly for use in studying the dynamics of disease transmission. Because of its known ability to infect via inhalation, biological weapons programs—including that of the United States during World War II—researched the possibility of using *M. tuberculosis* bacteria as a biological warfare agent. It was quickly discounted as a plausible weapon, primarily because TB was not as infectious as other pathogens. Nor were symptoms from TB disease fast-acting or dramatic enough to make a difference on the battlefield.

Although TB is very contagious—it was once the number-one killer in the United States—it is not considered an immediate biological threat, because infection can be prevented, cured, and detected using the tuberculin skin test. The general U.S. population is not vaccinated with the TB vaccine (Bacillus Calmette-Guerin or BCG) in part because this can confound the tuberculin skin test, and currently is not viewed as being worth the risk for infant inoculations. Although many children and infants in developing countries are vaccinated, TB is increasing globally, killing approximately 2 million people per year. This is partly due to the emergence of multi-drug-resistant strains that pose a higher mortality rate and require more aggressive treatment.

—Beverley Rider

See also: Aerosol; Vaccines

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TYPHUS (RICKETTSIA PROWAZEKII)

Typhus (caused by *Rickettsia prowazekii*)—not to be confused with typhoid fever (caused by *Salmonella typhi*)—is an infectious disease caused by a rickettsial pathogen, bacteria that usually need a host to survive and reproduce. It is considered a potential biological warfare (BW) agent. Some other forms of rickettsial illness, including scrub typhus (*Rickettsia tsutsugamushi*), are also mentioned in BW defense literature as potential BW agents. The classic, epidemic form of typhus is transmitted by the human body louse *Pediculus,* and reservoirs for the pathogen include rats and other rodents such as the flying squirrel. Although it is no longer considered a significant threat today, biological warfare (BW) programs in the past have investigated typhus as a potential biological weapon, including the United States (during World War II) and the former Soviet Union.

Natural outbreaks of typhus are occasionally seen in developing countries, but the classic (louse-borne) epidemic typhus has not been seen in the industrialized world for decades. In the classic form of the illness, *R. prowazekii* organisms multiply at the focus of the insect bite. These parasitic bacteria grow within the cellular tissue, causing infected cells in the host to rupture. The organisms are then released and migrate to the regional lymph nodes. Systemic infection follows, producing sudden onset of chills, fever, headache, and other flulike symptoms 1–3 weeks after the bite. A rash appears after several days during the course of the disease (thus the name spotted fever). Stupor and delirium eventually set in, sometimes leading to serious complications such as gangrene.

If the disease is left untreated, the death rate from epidemic typhus is approximately 10 to 50 percent, but timely administration of antibiotics should bring about full recovery. The most effective measures to prevent typhus have included rodent control, as well as insect abatement through the use of insecticides (particularly DDT). Although some have claimed that typhus vaccines contributed to the eradication of the disease from the developed world, no vaccine has yet found widespread acceptance.

Background

Especially in the preantibiotic era, disease played a major role in military conflict. Of all diseases affecting troops and civilians in times of war, typhus probably claimed the most lives. The Greek historian Thucydides, for example, wrote about the "plague of Athens." Although the etiologic agent has yet to be identified, what he described closely matches the description of typhus, which probably spread to the civilian population by Peloponnesian troops in about 425 B.C.E. Typhus also probably played a major role in defeating Emperor Napoleon's campaign in Russia. In 1812, France lost up to 80,000 men from disease, especially from epidemic typhus (*R. prowazekii*). Tight living quarters and poor hygiene contributed to lice-infested conditions. Napoleon's subordinates reported that their comrades were swarming with lice, and not long after, many came down with spotted fever, the old name for typhus.

Later, in the formative years of the Soviet Union, epidemic typhus was rampant. From 1918 to 1921, as many as 30 million people were affected, and 10 percent of these died. Dr. Kenneth Alibek, former deputy director of the Soviet biological weapons program, suggests that it was this experience that helped convince Red Army commanders to pursue biological weapons development, including the use of typhus as a biological weapon. In 1928, military biologists in the Soviet Union grew *R. prowazekii* in chicken embryos and rats. Using industrial-grade blending equipment, the animals' infected tissues were liquefied into crude BW agent preparations. Also, according to Dr. Alibek, by the 1930s, the Soviets had produced both liquid and dried forms of typhus for use in biological weapons.

Although there is no evidence of deliberate use of BW agents by either side during World War II, Soviet officials suspected that Germany deliberately infected Red Army troops with typhus. According to one Soviet retrospective on the Battle of Stalingrad, the retreating German army purposefully left behind foci of infectious disease: "the fascists imposed distinctive, epidemiological diversities aimed at injuring our troops: they threw across the front line the lice-ridden victims of spotted fever [that is, typhus] and prior to their back off dissolved the camps of war prisoners and civilian population infected by spotted fever" (Agafonov and Tararin, p. 7). It cannot be proven that the German military purposefully spread typhus in this manner. (During the Battle of Stalingrad, the number of German casualties due to typhus nearly equaled the number of battlefield injuries.)

Although a typhus vaccine was available during World War II, its real efficacy has always been in doubt. By far the greatest factor in the reduction of typhus was the introduction of DDT to kill its main vector, lice. The United States Typhus Commission, formed in December 1942, was established in the War Department. In early 1943, Merck & Company produced about 500 gallons of DDT, which was immediately sent to Naples, Italy, for use in delousing. This proved to be an effective demonstration of how the application of DDT could halt a fast-growing typhus epidemic. Following the war's end, DDT was instrumental in processing many German prisoners of war, many of whom were infected or were vulnerable to infection by typhus. Few, if any, of this population had been vaccinated for typhus, and many German soldiers were ridden with lice. Since World War II, DDT has saved untold lives, not just from of typhus but from many other arthropod-borne diseases.

In 1965, the Indian intelligence apparatus became suspicious during the Indo-Pakistan war following an outbreak of scrub typhus in northeast India, raising the possibility that Pakistan was using some sort of biological weapon. Caused by the organism *Rickettsia tsutsugamushi,* scrub typhus had first been introduced to the American hygiene lexicon during Commodore Matthew Calbraith Perry's visit to Japan in 1853, and it became a problem later during the Pacific campaigns of World War II. In the preantibiotic era, fatality rates from scrub typhus reached 35 percent. Despite India's suspicions, the presence of scrub typhus during the Indo-Pakistan war was undoubtedly a natural consequence of the war's disruption of hygiene and displacement of people.

—Eric A. Croddy

See also: Biopreparat; Russia: Chemical and Biological Weapons Programs

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T-2 TOXIN

See Yellow Rain

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UNIT 731

Unit 731 was the first modern biological weapons unit. It was organized by Japanese troops and conducted heinous crimes in China during World War II. Unit 731 was also referred to as "General Ishii's Unit" because it was organized by Japanese Lieutenant General Shiro Ishii, a military surgeon.

In 1930 or 1931, General Ishii proposed to the Japanese Army that pathogenic bacteria could be used as a weapon. In August 1932, the Laboratory of Preventive Medicine was set up within the College of Military Medicine. In 1933, a Unit of Preventive Medicine in the Kwantung army was set up in the city of Harbin, Manchuria. The name was eventually changed to Kwantung Army Institute of Preventive Medicine. General Ishii was given formal command of the Kwantung Army Institute of Preventive Medicine, including its 1,300 military personnel, in 1936. In the Institute, the Japanese tried to weaponize plague, cholera, anthrax, *Shigella dysenteriae*, typhoid fever, tularemia, botulism, brucellosis, gangrene, glanders, influenza, meningococcus, *Salmonella*, smallpox, tetanus, tick encephalitis, tuberculosis, and typhus. Some toxins such as puffer fish (*Fugu*) toxin (i.e., tetrodotoxin) were also investigated. Tsutsugamushi fever, which is caused by rickettsia, and epidemic hemorrhagic fever were also studied.

Personnel under Ishii's command used Chinese prisoners, dissidents, and spies as human specimens to study the effects disease and biological weapons. Altogether, about 3,000 people were sacrificed to obtain firsthand knowledge of the effects of different bacteria on humans. Despite the large scale of its biological warfare research, the identity of the Institute was kept secret.

Weaponization of bacteria was not an easy task, and General Ishii's goal was to develop a bomb that could be delivered from an airplane to cause massive outbreaks of deadly diseases. He found that the bacteria alone were not suitable for spreading disease; he thought that fleas carrying plague were the most suitable vector for a biological weapon attack. Therefore, mass breeding of disease-carrying fleas was undertaken, using rats as hosts. Eventually the Japanese developed a porcelain bomb that incorporated a minimum amount of explosive (in order to protect the viability of the insects inside) to attack targets with plague-carrying fleas. Upon impact, the bomb's porcelain shell was to break, and fleas were to be released, eventually reaching and biting humans. One bomb of this type carried 30,000 fleas. The survival rate of fleas when the bomb exploded was perhaps as high as 80 percent. Porcelain bombs also were made for anthrax, typhoid, and dysentery.

For the anthrax bomb, Ishii used the spore form of anthrax because of its extreme stability. When the bomb exploded, shrapnel fragments were to cause wounds through which anthrax spores entered the body. Modern-day biological weapons makers prefer to develop aerosol weapons, as the inhalation route of infection typically causes more severe disease.

At the end of World War II when Soviet Union troops invaded Manchuria, the Japanese destroyed the buildings and facilities of Unit 731 and returned all its personnel to Japan before they could be captured by advancing Soviet troops. Even so, some personnel associated with Unit 731 were arrested by the Soviets. In December 1949, these persons were trotted out in a show trial, and given sentences ranging from 3 years to 25 years by the Soviet Military Court. However, most of them were sent back to Japan without serving the full terms of their prison sentences.

The U.S. Army was surprised to see the advanced stage of the Japanese biological weapons program and tried to learn from General Ishii's group in Japan. Instead of punishing them as war

Chinese protestors claimed their relatives were killed by Unit 731 BW scientists (2002). (Reuters/Corbis)

criminals, the United States protected them in an effort to obtain the information generated by Unit 731's experiments.

—*Anthony Tu*

See also: Sino-Japanese War

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UNITED KINGDOM: CHEMICAL AND BIOLOGICAL WEAPONS PROGRAMS

The United Kingdom's chemical and biological warfare programs developed in response to the perceived threat posed by other nations' efforts to develop chemical and biological weapons. The development of British chemical weapons, for example, followed German attacks on elements of the British Expeditionary Forces in 1915. The biological program started shortly after the beginning of the Second World War in response to concerns about possible Nazi interest in germ warfare.

Chemical Warfare

During World War I, chemical agents—sulfur mustard, chlorine, phosgene, and chloropicrin—were developed and manufactured at a new facility at Porton Down, while substantial progress was being made in protection against chemical attack through the development of gas masks. In addition to the battlefields of the western front, German cities were also considered as targets for chemical attacks. But this option was not taken, and the British limited their use of chemical weapons to the western front. Overall, the British suffered about 185,000 casualties from gas attacks during World War I.

During the interwar period, British opposition to the use of chemical and biological weapons grew. Successive British governments supported the idea of banning chemical weapons, and Great Britain signed the 1925 Geneva Protocol upon its conception, and ratified it in 1930. Britain, however, refused to completely abandon its chemical warfare capabilities; it accepted in principle the no-first-use concept but insisted on maintaining a deterrent. In the years preceding the Second World War, extensive preparations were made for civil defense based on the assumption that Germany, Italy, and Japan were likely to use chemical weapons against British forces in the field and that a threat existed to the civilian population.

During the Second World War, research at Porton Down was expanded and production was increased to ensure that sufficient chemical deterrent stocks were available in all theaters of war. In addition to experiments with the new insecticide DDT, the British discovered compounds that could be used as nerve agents, but they failed to realize these compounds' significance. Nevertheless, the toxic organophosphate nerve compound diisopropyl fluorophosphate (DFP) was developed, and, although less deadly than tabun or sarin, it significantly enhanced the effect of mustard gas when the two were mixed together. The new compound produced a dual effect from both blister and nerve agents in terms of causing casualties, and the mixture could remain a liquid under colder temperatures than mustard agent alone. Although U.S. and European armies used no chemicals during World War II, the production of chemical weapons on both sides—the Axis and the Allies—was considerable. In 1944, after the Germans started using V1 and V2 ("Vengeance") cruise missiles and ballistic rockets against London, the British came close to a preemptive use of mustard and other chemicals against German cities.

In the immediate postwar world, the British, in conjunction with the United States and Canada, pooled their knowledge of the German nerve gases tabun, sarin, and soman and conducted tests with these agents. With funding being short, however, the British government placed greater emphasis on its nuclear and biowarfare programs and less on its chemical program. As a result, the United Kingdom never went into full-scale production of the new nerve agents before deciding in 1956 to renounce the offensive use of chemical weapons under any circumstances.

Since 1956, all British chemical warfare research has focused on providing for defensive equipment. The United Kingdom has become a world leader in protective gear, including the use of ion mobility spectroscopy—the use of measuring ionized particles to determine the identity of a substance—in hand-held chemical agent detection systems. The United Kingdom also signed the 1993 Chemical Weapons Convention (CWC) as part of general efforts to eliminate chemical arsenals worldwide.

Biological Warfare

In Britain, fears about biological warfare first became public in 1934 in the Wickham Steed Affair, when claims were made that German spies had tested biowarfare agents on the London Underground and Paris Metro. Within a year of the outbreak of the Second World War, a new biology department was set up at the chemical warfare establishment of Porton Down to develop a bioweapon that could be used to retaliate against a German biological weapons attack. The department focused its efforts on anthrax bacterial spores and botulinum toxin (derived from *Clostridium botulinum* bacteria).

Two weapons were developed. The first consisted of 5 million linseed cattle feed cakes filled with a slurry of anthrax spores and stockpiled as an antilivestock weapon ("Operation Vegetarian"). These cakes were to have been dropped over livestock grazing areas in Germany by aircraft, but the operation was never carried out. The second weapon was a prototype antipersonnel anthrax bomb that was tested on Gruinard Island off the coast of Scotland. After 50 years of isolation due to safety concerns about the possibility of lingering anthrax spores, this island has now been decontaminated and returned to its previous owner (*see* Gruinard Island).

With the end of the Second World War, the government gave the biowarfare program equal priority with the atomic program, and a series of tests were undertaken with the pathogens responsible for diseases such as brucellosis, tularemia, and plague. British interest in biowarfare receded with Britain's first atomic test in 1952. In 1972, the United Kingdom signed the Biological and Toxin Weapons Convention, ending research into offensive biological warfare. A pool of British scientists, however, remains engaged in developing protective equipment and treatments for defense against biological attack.

—Andrew M. Dorman

See also: Gruinard Island; Porton Down; World War II: Biological Weapons; World War II: Chemical Weapons

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UNITED NATIONS MONITORING, VERIFICATION, AND INSPECTION COMMISSION (UNMOVIC)

In 1999, the United Nations Security Council, acting under Chapter VII of the UN Charter, established the United Nations Monitoring, Verification, and Inspection Commission (UNMOVIC) to undertake the responsibilities of the UNSCOM (United Nations Special Commission on Iraq). (*See* United Nations Special Commission on Iraq [UNSCOM].)

In response to Iraqi insistence, UNSCOM withdrew its staff from Iraq on December 16, 1998, and ceased to function. United Nations Security Council Resolution 1284 (December 17, 1999) created UNMOVIC to replace the former UN Special Commission. The commission had been assigned to dismantle Iraq's program to acquire weapons of mass destruction (chemical and biological weapons, and missiles with a range of more than 150 kilometers) and to operate a system of ongoing monitoring and verification along with the International Atomic Energy Agency (IAEA). UNMOVIC was to check Iraq's compliance with its obligations not to develop or possess weapons prohibited to it by the UN Security Council. From its creation until November 27, 2002, however, UNMOVIC carried out no inspections, due to Iraq's refusal to cooperate with inspection teams.

On September 16, 2002, following UN Resolution 1441, which was introduced by the United States and found the Iraqi government to be in material breach of its obligations to verifiably disarm, the foreign minister of Iraq informed the UN secretary-general that Iraq had decided to allow the return of UNMOVIC and IAEA inspectors without conditions. Inspections resumed on November 27, 2002. UNMOVIC took over UNSCOM's assets, liabilities, and archives and was required to report to the UN Security Council every 3 months. Dr. Hans Blix of Sweden served as UNMOVIC's executive chairman, and sixteen other individuals served on the College of Commissioners that provided advice and guidance to Blix in the execution of his duties. UNMOVIC's staff included weapons specialists, analysts, scientists, engineers, and operational planners. It was financed from a small portion of the monies raised from the export of oil from Iraq (the "oil-for-food" program, allowing purchases of items for humanitarian purposes, such as food and medicine, in exchange for crude oil). Unlike UNSCOM, all the staff of UNMOVIC were employees of the United Nations.

UNMOVIC comprised four divisions (Planning and Operations, Analysis and Assessment, Information, and Technical Support and Training) and an administrative service, headquartered at the UN in New York. On resumption of inspections, a transport and supply system was established in Cyprus with regular flights to Baghdad, where more than 100 inspectors operated daily along with IAEA inspectors. Their duties included interviewing Iraqi scientists; UNMOVIC personnel also held consultations with interested IAEA member states on revisions to the list of dual-use goods and chemical, biological, and missile equipment to which the UN-monitored export/import mechanism applied. It submitted these modified lists of contraband materials to the Security Council.

UNMOVIC produced an interim report to the Security Council on January 9, 2003, after completing 250 inspections. In making the report, Blix noted that Iraq's most recent declaration to UNMOVIC was incomplete and left many questions unanswered. UNMOVIC evacuated its staff from Iraq on March 17, 2003, following Iraq's rejection of President Bush's ultimatum to disarm. On March 19, a U.S.-led coalition invaded Iraq, intending to once and for all eliminate suspected Iraqi WMD and missile programs. The UN Security Council will now determine UNMOVIC's future mandate.

—*Glen M. Segell*

See also: Iraq: Chemical and Biological Weapons Programs; United Nations Special Commission on Iraq [UNSCOM]

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UNITED NATIONS SPECIAL COMMISSION ON IRAQ (UNSCOM)

In addition to its work to disarm chemical, biological, and missile-related technologies in Iraq's known weapons of mass destruction (WMD) program, the United Nations Special Commission on Iraq (UNSCOM) was formed to assist the International Atomic Energy Agency (IAEA). The latter's mandate was to provide evidence of the destruction, removal, or demilitarization of Iraq's nuclear facilities and ballistic missiles with a range greater than 150 kilometers, including the launchers, production, related major parts, and repair facilities of such missiles. UNSCOM was also charged with undertaking a monitoring program to ensure that Iraq could never reconstitute its chemical, biological, and nuclear arsenal.

After losing the 1991 Gulf War, Iraq agreed, as a condition of surrender, to declare within 15 days all of its WMD and the means (rockets, artillery shells, etc) to deliver them, and then to destroy them. This obligation was reinforced by U.N. Security Council Resolution 687 on April 3, 1991, which formed UNSCOM to monitor and verify Iraq's compliance with its undertaking not to use, develop, construct, or acquire chemical, biological, and nuclear weapons.

Under the terms of the resolution, Iraq was barred from selling oil until UNSCOM verified the destruction of its prohibited weapons. The nuclear inspection teams were organized by the IAEA, with the assistance and cooperation of the Special Commission. UNSCOM commenced its first missile inspection on June 30, 1991. Iraq consistently tried to evade its responsibilities, and following Iraqi efforts to deter its mission, UNSCOM withdrew its entire staff from Iraq on December 16, 1998.

Iraqi Long-Range Missiles

On April 18, 1991, Iraq provided an initial declaration that it possessed fifty-three al-Hussein and Scud-type long-range ballistic missiles. From September 21 to 30, 1991, IAEA inspectors first found large amounts of documentation relating to Iraq's efforts to acquire nuclear weapons. Following this, the IAEA, with the assistance and cooperation of UNSCOM, undertook fifty-three ballistic missile and thirty nuclear inspections. UNSCOM supervised the destruction of forty-eight operational long-range missiles, fourteen conventional missile warheads, six operational mobile launchers, twenty-eight operational fixed launch pads, thirty-two fixed launch pads that were under construction, thirty missile chemical warheads, and other missile support equipment and materials. It also supervised the destruction of a variety of assembled and nonassembled "super-gun" components. The super-gun concept employs an extremely long barrel that could conceivably fire projectiles over hundreds, possibly thousands, of kilometers.

UNSCOM was instrumental in assisting the November 1995 interception by the nation of Jordan of a large shipment of high-grade missile components destined for Iraq. The Commission's experts also participated in negotiations with the Russian Federation regarding the sale of the nuclear fuel removed from Iraq and reprocessed in the Russian Federation. The disclosures of Iraq's nuclear program led to efforts to strengthen the IAEA safeguard agreements used to monitor and verify compliance among parties to the Nuclear Nonproliferation Treaty (NPT).

On December 17, 1999, the UN Security Council adopted Resolution 1284, replacing UNSCOM with the United Nations Monitoring, Verification, and Inspection Commission (UNMOVIC).

—*Eric A. Croddy*

See also: Iran-Iraq War; Iraq: Chemical and Biological Weapons Programs; United Nations Monitoring, Verification, and Inspection Commission (UNMOVIC)

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UNITED STATES: CHEMICAL AND BIOLOGICAL WEAPONS PROGRAMS

During the twentieth century, the United States developed one of the largest arsenals of chemical and biological weapons in the world, second only to that of the former Soviet Union. Since the ratification of the 1975 Biological and Toxin Weapons Convention (BTWC) and the 1993 Chemical Weapons Convention (CWC), the United States has demilitarized its biological and chemical weapons programs. As of 2004, no offensive biological weapons exist in the United States, but thousands of tons of chemical weapons remaining on U.S. soil await their final destruction in keeping with the terms of the CWC.

Chemical Warfare

The potential use of chemical agents, in the form of poisonous gases or substances to contaminate water wells, was considered early in U.S. history. In 1862, during the Civil War, an American engineer by the name of John W. Doughty wrote to the U.S. Secretary of War, suggesting that chlorine be used in artillery shells. He believed that the introduction of chemical weapons on the battlefield would lead to more decisive results. It is not certain whether this plan inspired U.S. Army General Order No. 100, issued in 1863, which admonished: "The use of poison in any manner, be it to poison wells, or food, or arms, is wholly excluded from modern warfare" (Smart, p. 13).

Little development in the area of chemical warfare (CW) in the United States occurred after that until 1915, when chemicals were used on a large scale for the first time. Because the United States had yet to become involved in the European hostilities of the time, efforts in "gas warfare" were mostly limited to the manufacture of protective equipment, especially gas masks. Six years prior to the conflagration in Europe, in 1908, Van H. Manning, director of the U.S. Bureau of Mines, had organized a department of scientists and engineers to develop equipment to protect coal miners from toxic gases in the mines. Research included the use of self-contained breathing apparatuses and medical treatment for personnel exposed to poisonous gases. In February 1917, Director Manning suggested that the Bureau could assist in testing gas masks for the U.S. Army. This was the only significant CW work that had been conducted by the time the United States declared war on Germany on April 6, 1917.

When U.S. troops entered the combat of World War I in 1917, however, it became clear that the American Expeditionary Forces were woefully unprepared for the chemical battlefield. The U.S. Chemical Warfare Service (CWS), led by Major General William L. Siebert, was founded on June 29, 1918. But by early September 1917, a "Gas Service" had already been established as a separate branch of the American Expeditionary Force (AEF) in France.

In May 1917, the CWS Research Division—in coordination with American industrial entities that included Goodyear Rubber, American Can Company, and the General Chemical Company—undertook a crash development program to supply the first 20,000 gas masks to U.S. forces. The issue of quality control—paramount in the case of chemical defense equipment—was dealt with in an interesting way. Those employees who had relatives serving in the AEF were chosen first to participate in the gas mask project. Workers who had a personal interest, it was reasoned, would be expected to make a higher-quality mask. When full-scale production was achieved, more than 40,000 masks could be produced in a single day, and eventually 5.7 million gas masks were manufactured by the end of World War I.

The U.S. military began filling chemical shells under the auspices of the Trench Warfare Section of the Ordnance Department. The Offense Research Section of the CWS selected certain substances for their possible use in combat. Approximately 250 chemicals were researched and evaluated for their suitability as chemical weapons for the western front. Although chemical weapons used by U.S. forces in the European theater were initially provided by the European allies of the United States, phosgene, mustard, and lewisite production facilities were built in the United States from 1917–1918. (Lewisite was a late entry into the U.S. chemical arsenal, and it was never used in World War I.) Because of its isolated location and ready access to shipping via Chesapeake Bay, "Gunpowder Reservation," 20 miles east of Baltimore, Maryland, was chosen in December 1917 to be the site for producing toxic agents and filling chemical shells and bombs. On May 4, 1918, the 3,400-acre district was officially renamed Edgewood Arsenal.

Except for the highly toxic nature of the chemicals being put into shells, the methods employed at the Arsenal were in many ways similar to those used by the bottling industry to handle carbonated water. The dangerous nature of the chemicals demanded special measures, however, including sealed-off rooms and automated equipment. But these protective measures were quite basic, and working conditions were still extremely hazardous.

By war's end, Edgewood Arsenal had filled and shipped more than 150,000 mustard shells of 75-millimeter caliber to the western front. Despite these efforts, none of the gas projectors or chemical artillery shells arrived in Europe before the fighting ended.

Following the end of World War I, the CWS had to struggle to remain intact as a formal organization in the U.S. military, surviving due almost solely to the efforts of Major General Amos A. Fries. In the late 1920s, the U.S. chemical arsenal consisted mostly of mustard, chloroacetophenone

Table U-1: Chemical Products, Intermediates, and CW Agents Produced at Edgewood Arsenal, 1918

Material	*Amount in millions of lbs.*
Salt (NaCl)	17.4
Bleach (sodium hypochlorite)	42.4
Picric acid	3.7
Alcohol	3.7
Sulfur	24.9
Sulfur chloride	6.6
Bromine	0.24
Material	*Amount, millions of lbs.*
Chlorine (liquid)	5.4
Chlorine (gas)	2.2
Chloropicrin	5.5
Phosgene	3.2
Mustard	1.4

(CN), phosgene, lewisite, chloropicrin, and chlorine. In 1928, the M1 4.2-inch chemical mortar became the standard chemical delivery system in the U.S. arsenal. It was also used to deliver obscurant smokes and high explosive shells. But with defense spending cut by the Great Depression, preparations for CW took a low priority for the United States War Department. In the late 1930s, the U.S. military had only 5 percent of the chemical munitions and only 3 percent of the number of gas masks thought necessary for 6 months of war. The U.S. armed forces were also not prepared for chemical contingencies.

In 1937, as war loomed once again on the European continent, the United States revamped its offensive chemical weapons program, adding production capacity at Edgewood Arsenal. But the agents produced, mustard and phosgene, were of World War I vintage. In comparison to the groundbreaking work in military chemistry going on in Germany and elsewhere, the United States had only a limited chemical warfare capability when it declared war on Germany and Japan. Especially in light of the Japanese military's use of CW against China in the 1930s, a sense of urgency prevailed to increase the U.S. offensive chemical stockpile. From 1940 to 1945, the United States ramped up its chemical production capacity, producing nearly 150,000 tons of CW agents. In addition to the already venerable 4.2-inch chemical mortar, other delivery ordnance included 75-millimeter, 105-millimeter, and 155-millimeter artillery rounds. (The 155-millimeter has since found wide acceptance for use with chemical rounds in other countries.) In addition to artillery, the U.S. Army Air Corps standardized aerial munitions, including 1,000-pound bombs containing phosgene, cyanogen chloride, and hydrogen cyanide. Substantial chemical weapons were deployed to European staging grounds, including Bari, Italy. Bari became the scene of a chemical disaster when German aircraft attacked Allied shipping vessels, including the SS *John Harvey,* which was laden with 2,000-pound mustard bombs.

In June 1943—reflecting the general disapproval of chemical warfare by the American public—Franklin D. Roosevelt categorically stated, "we shall under no circumstances resort to the use of such weapons unless they are first used by our enemies" (Smart, p. 44). By 1945, however, public mood had shifted: 40 percent of the people responding to one survey were in favor of using chemicals against the Japanese, versus 23 percent just a year before. Pitched battles in the Pacific island campaign had resulted in horrendous U.S. casualties, not to mention the massive loss of civilian life during the Okinawa campaign. This no doubt added to the public's acceptance of offensive CW. Defending from heavily fortified redoubts, Japanese troops rarely surrendered and fought ferociously to the very end. It was at this point that the U.S. Assistant Secretary of War, John J. McCloy, reconsidered the use of chemical weapons.

As plans were being drawn to invade the Japanese mainland, General "Vinegar Joe" Stilwell and General George C. Marshall suggested the use of gas. But the logistics and preparation for such CW would have conflicted with the shipment of sorely needed conventional materiel. Other influential decision makers within the military, notably Admiral William D. Leahy, thought it appalling that the employment of chemical weapons was being considered. In 1945, the United States could have mustered enough chemical weapons from existing stocks, and with its industrial capacity manufactured many thousands of tons more, to have conducted a debilitating attack against the Japanese military deployed in defense of the home islands. But without gas masks and other equipment being forward deployed—not to mention the lack of CW training among U.S. troops—practical considerations and moral qualms recommended against the use of CW against the Japanese. (Nonetheless, the ferocious nature of the battle for Okinawa did contribute to the decision to drop the atomic bomb on Japan.)

The discovery of Germany's nerve agent stocks, including 750 tabun artillery shells that were captured in Germany and shipped to the United States, was a shock to Allied CW experts. By the 1950s, sarin nerve agent and VX were produced in large quantity by the United States at Mussel Shoals, Alabama, and Newport, Indiana, respectively. By 1954, the M34 and M34A1 chemical cluster munitions were designed to drop sarin on targets. Little progress was made in delivering VX nerve agent, however, until the 1960s. During this time, incapacitants were researched and tested, often on human volunteers, leading to the weaponization of BZ (3-quinuclidinyl benzilate). Mortars, artillery rockets (M55), and land mines containing sarin or VX were produced. Longer-range systems, including the Honest John (16-mile range) rocket and the Sergeant rocket, were fitted with chemical warheads. During the 1960s, unmanned aerial vehicles (UAVs)—more accurately described as drone aircraft—were developed to deliver both chemical and biological agents. An accident on Okinawa, Japan, involving sarin nerve agent, however, led to a halt to both biological and chemical weapons production by the United States in 1969.

The aftermath of the 1973 Yom Kippur War in the Middle East served as yet another "wake-up call" for the U.S. Chemical Corps. Israeli forces, which barely prevailed after Egypt and Syria launched a surprise attack, discovered Soviet armored vehicles that were equipped to survive in contaminated chemical environments. This spurred the United States to rethink its approach to defensive and offensive CW. More advanced designs for chemical munitions, including the M-687 binary shell, were integrated into U.S. chemical weaponry in 1976.

Not without controversy, in the 1980s President Ronald Reagan revitalized U.S. offensive chemical weapons production. Defending his decision, Reagan stated, "the United States must maintain a limited [chemical] retaliatory capability until we achieve an effective ban" (Smart, p. 70). Not only the M-687, but also the VX binary bomb (Bigeye), went into full production by the late 1980s. Although these and other chemical weapons were available by the 1990–1991 Gulf War, they played no role in planning for retaliation in the event that Iraq introduced chemical weapons on the battlefield.

Having signed a memorandum of understanding with the former Soviet Union in 1989, the United States was set on a course to fully demilitarize its chemical arsenal, culminating in the ratification of the Chemical Weapons Convention in 1997. As of 2004, about 28,000 tons of chemical agent in bulk and weaponized form awaited their final destruction in the United States.

Biological Warfare

Before the renunciation of biological warfare by President Richard M. Nixon in 1969, the United States developed a series of weaponized BW agents. These included the causative agents of anthrax, brucellosis, tularemia, Venezuelan equine encephalitis, and Q-fever, as well as the toxin staphylococcal enterotoxin B. Anticrop agents were also produced in significant quantity to target the wheat and rice crops of communist Russia and China during the Cold War. A number of other BW agents, including smallpox, rift valley fever virus, and Rocky Mountain spotted fever bacteria were investigated as well. All offensive biological weapon stores were destroyed by 1972, and some toxins (such as saxitoxin) were redirected toward peaceful medical research.

Referring to a League of Nations committee formed on the subject, the U.S. Chemical Warfare Service wrote in its 1926 annual report that BW "would have little effect on the actual issue of a contest in view of the protective methods which are available for circumscribing its effects" (U.S. CWS, pp. 8–9). Later in the 1930s, however, prewar intelligence reports indicated that Japan and Germany had undertaken research into offensive BW. In February 1939, the U.S. State Department reported that a Japanese army physician in New York had tried to obtain yellow fever virus, possibly an attenuated strain, from the Rockefeller Institute for Medical Research. This and other intelligence reports contributed to a newfound sense of urgency, and in September 1939, American military scientists decided to reexamine the problem of BW.

The Chemical Warfare Service reported that nine diseases could be potential BW agents: yellow fever, the dysenteries, cholera, typhus, bubonic plague, smallpox, influenza, sleeping sickness (*Trypanosoma brucei,* via the tsetse fly), and tetanus. These agents were of great interest because they could be spread by insects, or because they required neither existing skin lesions nor did they need another agent to enter the human body. Although doubts still persisted in the United States about the real threat posed by BW, information in late 1939 indicated that Japan and Germany were interested in the subject. A consensus was reached to allocate funds for defensive research against biological weapons.

In 1941, the U.S. Chemical Warfare Service began BW-related research. In February 1942, the National Academy of Sciences (NAS) submitted a report to Secretary of War Henry L. Stimson describing the threat posed by BW agents against crops, livestock, and humans. The NAS concluded that both defensive and offensive BW research be conducted. In mid-1942, George W. Merck, President of Merck & Company, a large pharmaceutical company, became the chairman of the War Research Service (WRS), which was established to oversee U.S. BW-related activities. The CWS was given the responsibility of building and operating laboratories and production facilities. In March 1942, the CWS had suggested that, in addition to work conducted by civilian research scientists in biological weapons defense, the following BW agents be studied in an offensive context:

Antipersonnel:

- Coccidioidomycosis
- Psittacosis
- Plague
- Typhoid and paratyphoid
- Cholera
- Typhus
- Yellow fever
- Anthrax

Antianimal:

- Rinderpest
- Foot-and-mouth disease
- Fowl plague

Anticrop:

- Late blight of potato
- Rice fungi
- Wheat rusts
- South American rubber leaf blight

By 1944, this list had grown by adding the following agents:

Antipersonnel:

- Tularemia
- Brucellosis
- Glanders
- Melioidosis

Anticrop:

- Sclerotium rot

By 1942, the CWS began construction of a BW facility at Camp Detrick, Maryland (later renamed Fort Detrick) at a cost of $13 million. Operational in 1943, the facility at Camp Detrick employed approximately 4,000 people. Other BW-related facilities included a 250-acre site near Dugway Proving Grounds, Utah, and a 2,000-acre facility at Horn Island in Pascalouga, Mississippi, both of which were used for open-air testing.

Meanwhile, cooperation among the United States, Canada, and England continued in BW research. It was learned from tests conducted by the British at Gruinard Island (off the coast of Scotland) and Penclawdd (on the coast of Wales) during 1942 and 1943 that loading anthrax into bomblets arranged into cluster munitions was the most feasible method of agent delivery. In one experiment, sheep were placed at various distances from a bomb loaded with anthrax fill. The reach of the deadly spores was such that animals placed 250 yards downwind received a lethal dose of anthrax. Despite these results, effective cluster-type munitions using anthrax were never supplied to Allied forces in World War II.

In the period following World War II, U.S. BW production capacity was gradually reduced to laboratory-scale research and development. Between 1947 and 1949, small-scale, open-air testing of BW simulants *Bacillus globigii* (BG) and *Serratia marcescens* (SM) was carried out at Camp Detrick. Pathogen tests began at Camp Detrick in 1949 in an enclosed, one-million-liter steel sphere called the "eight ball." During the Korean War, the United States expanded its BW program. The government established the Pine Bluff Arsenal BW agent production facility in Arkansas, and it also expanded major research facilities at Camp Detrick. By 1951, the program developed, tested, and produced a variety of BW anticrop agents for military purposes and the bombs capable of delivering such agents. Spending on BW-related research and development amounted to more than $345 million during fiscal years 1951–1953. By September 1952, however, the ability to deliver biological agents effectively was still an open question, and it had become apparent, at least to the U.S. Air Force, that the United States still had no lethal, stable, viable, easily disseminated, low-cost, epidemic-producing BW agent.

During the 1950s, the U.S. military conducted a number of secret tests to assess the vulnerability of the American mainland to BW attack, or to test the effectiveness of BW agent delivery methods. Exercise Brown Derby was carried out November 7–20, 1953, by the Chemical Corps and U.S. Air Force to assess the ability of the United States to produce and transport BW weapons overseas. The exercise showed that an attack using BW could be launched within several days of the initial order. Operation Big Itch consisted of a series of field tests of E-23 and E-14 munitions loaded with *Xenopsylla cheopis* fleas, which in this case did not carry pathogens. The fleas were dropped from a height of 300 to 600 meters over guinea pigs on the Dugway Proving Grounds in 1954. Technical difficulties with the E-23 munition, however, caused fleas to escape into the plane, resulting in the bombadier, observer, and pilot all being bitten by the insects.

A series of at least three or four "Bellwether" tests, conducted beginning in the late 1950s, studied the biting behavior of mosquitoes. Bellwether 1, for example, was a study conducted in September–October 1959, during which uninfected, female *Aedes aegeypti* mosquitoes were released in fifty-two field trials and the number of mosquito bites on laboratory animals and on humans were counted.

Scientists from Fort Detrick also secretly performed animal studies at remote desert sites and on barges near Johnston Atoll in the Pacific Ocean. Between 1949 and 1968, the U.S. government also surreptitiously dropped BW simulants (such as *Serratia marcescens*) over a number of American cities, including San Francisco and New York City, to assess urban vulnerability to biological attack and to experiment with potential weapons and delivery systems. Simulants such as *Serratia marcescens* (SM) could be cultured at various points distant from release to determine length of travel. In 1955, American scientists and military experts began using human volunteers to test the effect of various BW simulants, including the anthrax simulant *Bacillus globigii* (BG). These tests were intended to help scientists learn how to strengthen American BW defenses, as well as to assist in developing the means to carry out a biological attack.

In 1956, further attention was brought to chemical and biological warfare, particularly as a result of the looming threat from the Soviet Union. In 1956, Soviet Defense Minister Marshal Georgi Zhukov's speech to the Twentieth Congress of the Soviet Communist Party in Moscow contained references to "weapons of mass destruction," including chemical weapons in future wars. The wording of the speech was used as support for the argument that a Soviet chemical threat existed, and by extension a threat from biological weaponry as well. A December 1958 meeting of the Defense Science Board recommended developing new unconventional weapons, expanding research, and placing greater resources into public relations. These recommendations, in turn, were supported by the Joint Chiefs of Staff in 1959. The Chiefs emphasized the need for stockpile modernization and increased research and development funding.

Despite increasing public interest in chemical and biological weapons disarmament during the 1960s, the American BW program continued to grow. The development of large-scale freeze-drying and spray-drying systems was undertaken to improve the ability of biological weapons agents to survive and remain potent during an offensive attack. Research using arthropods was conducted to deliver certain BW agents. By 1966, government facilities at Pine Bluff Arsenal and Fort Detrick had already mass-produced several BW agents, filling several types of biological munitions. The so-called Flettner rotor was designed to deliver BW agents in cluster-type munitions, but it was never mass-produced. The E120 bomblet was also developed to deliver biological weapons.

By the time the U.S. BW program was terminated in 1969, American BW scientists had seven standardized biological weapons. In the lethal category, the U.S. Army had weaponized the bacterial agents that cause anthrax and tularemia. For incapacitating agents, the causative agents of brucellosis, Q-fever, and Venezuelan equine encephalitis (VEE) were weaponized. Toxins that were developed into

CHRONOLOGICAL SKETCH OF THE U.S. BIOLOGICAL WEAPONS PROGRAM

1939	Possible threat from BW agents is reexamined in a study by the Chemical Warfare Service (CWS)
1941	Secretary of War Henry L. Stimson charges a committee from the National Academy of Sciences (NAS) to evaluate viability of biological weaponry
1941	NAS committee concludes BW is indeed a threat and recommends that vulnerability testing be performed for United States security in 1942
1943	Camp Detrick, Maryland, begins operations with a staff of approximately 4,000
1944	Dugway Proving Grounds, Utah, built as test site for pathogen/BW research
1945–1949	Some testing facilities are shut down, but small-scale outdoor testing using biological simulant (*Bacillus globigii*, or BG) is performed at Camp Detrick
1950	Expansion plans developed for BW research in response to threat from the Soviets
1953	Further construction of facilities at Camp Detrick, along with an increase in defensive and retaliatory BW research
1955	Pine Bluff Arsenal, Arkansas, produces large quantities of *Francisella tularensis* (the causative bacteria for tularemia)
1956	Marshal Georgi Zhukov of the U.S.S.R. delivers speech, stating that chemical/biological weapons were part of Soviet military doctrine; U.S. CBW policy reviewed, Camp Detrick changes name to Fort Detrick on February 3, 1956
1961	President John F. Kennedy reassesses BW, recommending expansion of BW programs
1964–1965	Production facilities for viruses and rickettsiae built at Pine Bluff Arsenal
1965	*Bacillus globigii* (BG) simulant used in (covert) vulnerability experiment on New York City subway system; tests conclude that many persons could be exposed to infectious doses of BW agents
1959–1968	Stable dry and liquid BW agents are developed, large-scale fermentation processes are improved, and effective dissemination munitions for microbes are manufactured
1969	President Richard Nixon renounces use of "lethal biological agents and weapons"
1970	President Nixon adds, "The United States will confine its military programs for toxins . . .to research for defensive purposes only"
1970–1972	Destruction of antipersonnel BW agents completed
1975	United States ratifies the Biological and Toxin Weapons Convention (BTWC)

validated weapons systems were the lethal toxin botulinum and the "incapacitant" staphylococcal enterotoxin B (SEB).

In 1969 and 1970, President Richard Nixon renounced all offensive development and production of microbial and toxin agents in National Security Directives 35 and 44, respectively. By 1972, all U.S. antipersonnel BW agent stocks and munitions were destroyed. The United States also terminated all offensive research, closed or cleaned up all offensive facilities, and turned these facilities over to other government agencies for other research. The American BW defense program was subsequently moved to Fort Detrick, Maryland. The unilateral disarmament initiated by President Nixon's directives set the stage for the 1972 Biological and Toxins Weapons Convention (BTWC). On January 22, 1975, the United States ratified the BTWC, which prohibited the development, production, and stockpiling of bacteriological and toxin weapons.

—*Eric A. Croddy*

See also: Aberdeen Proving Ground; Fort Detrick; World War I; World War II

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UNMANNED AERIAL VEHICLE (UAV)

An unmanned aerial vehicle is "a powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload. Ballistic or semiballistic vehicles, cruise missiles, and artillery projectiles are not considered unmanned aerial vehicles" (U.S. Department of Defense [DoD], online). Although some may consider cruise missiles and similar platforms as UAVs, most commentary reflects the U.S. definition of the term.

With applications ranging from battlefield reconnaissance to live target engagement, UAVs are a versatile and highly effective weapon. The United States, Germany, and the Soviet Union (now Russia) have been actively developing UAV technology—with varying degrees of success—since World War II. Recent use of UAVs in Operations Desert Storm, Allied Force, Enduring Freedom, and Iraqi Freedom has garnered significant public attention and convinced many senior leaders in the United States and elsewhere of their utility. In fact, some Pentagon officials now estimate that by 2015, UAVs will account for 10 percent of all U.S. aircraft. However, many of the characteristics that make UAVs attractive platforms for the United States and its allies also make them attractive to rogue states and terrorist organizations. Indeed, UAVs are potentially an effective delivery vehicle for chemical or biological weapons.

Although the United States has been experimenting with UAVs since the 1940s, it has only been within the past decade that U.S. policymakers and war planners have begun to realize the potential of UAVs. In the past, technology has been the most significant limiting factor. Advances in computer science and aerospace engineering, however, have transformed UAVs into a reliable platform for military operations. Indeed, U.S. Secretary of Defense Donald Rumsfeld was so impressed with the performance of U.S. UAVs during Operation Enduring Freedom (2001–2002) that he added approximately $1 billion to the DoD's UAV programs for fiscal year 2003.

UAVs enjoy many significant advantages over manned aircraft. UAVs are less expensive; the Air Force's Predator, for example, has a base cost of approximately $5 million, compared to manned fighter aircraft with price tags of two to four times as much. Such cost discrepancies will only increase as the systems needed by manned aircraft to defeat sophisticated enemy radar and ground defense systems become more complex. The UAV's biggest advantage, however, is that it can be employed for a variety of missions that are too dangerous for a manned aircraft. These include identifying enemy surface-to-air missile (SAM) batteries, triggering or locating enemy radar systems, or "parking" over the battlefield to transmit real-time video footage to the command center.

Background

U.S. attempts to develop UAVs began during World War II. For example, Operation Aphrodite involved the use of a pilot flying a specially modified airplane to a predetermined altitude. Once at the proper altitude, radio control of the first plane would be established by a pilot in another plane. At this point, the original pilot would parachute from the cockpit, allowing his plane to be flown via remote control to the target. It was during one of these Operation Aphrodite missions that President John F. Kennedy's older brother, Navy Lieutenant Joseph P. Kennedy, was killed. Germany had experimented with various unmanned aerial platforms as well during World War II.

Approximately 20 years later, UAV technology was employed in the jungles of Vietnam. The Air Force's AQM-34 Lightning Bug was the first U.S. photo reconnaissance UAV. It was used for photography, real-time video, electronic intelligence, communications intelligence, detection of SAM positions, and dropping leaflets in psychological operations. Despite the Lightning Bug's demonstrated utility, interest in UAV technology waned as

UAVs are the reconnaissance and combat platform of the future. Terrorists could also use them to deliver CBW agents. (Corbis/Sygma)

the Vietnam War came to an end. Significant interest in UAVs didn't emerge again until the 1980s.

Prompted by Israeli successes with UAV technology, the U.S. Navy began development of its Pioneer UAV in 1985. The Pioneer was a direct derivative of an existing Israeli UAV system and became the primary U.S. UAV during Operation Desert Storm (1991). In total, forty-three Pioneers were deployed during Operation Desert Storm, flying 330 sorties and completing more than 1,000 flight hours. The U.S. Army, Navy, and Marine Corps used the Pioneer for a variety of functions: destroying enemy artillery, providing imagery, and monitoring Iraqi troop movements.

The Navy also found that the Pioneer was highly useful for spotting targets for firing 16-inch guns from battleships that maintained station well out to sea. The U.S.S. *Missouri* used a Pioneer to spot for its guns as it bombarded Iraqi positions on Falakya Island, which was located off the coast near Kuwait City. As the U.S.S. *Wisconsin* arrived to relieve the U.S.S. *Missouri* and resume shelling the island, it sent its Pioneer to hover low over the Iraqi emplacements. At one point, some Iraqi forces even surrendered to a Pioneer. Hearing the Pioneer's motor and realizing that a new round of shelling was about to begin, the Iraqis frantically signaled their surrender. The DoD also used the Pioneer in military operations in Bosnia, Haiti, and Somalia. It was retired from service in 2000, however, due to production problems and cost overruns.

UAVs once again proved their worth in Operations Enduring Freedom and Iraqi Freedom, in which both the Predator and Global Hawk provided U.S. forces with valuable support. Although the Global Hawk gave U.S. forces the capability to receive timely and accurate reconnaissance, the Predator received more headlines, as it became the first UAV to engage and destroy enemy targets (when an armed Predator flying over Yemen engaged a vehicle carrying senior al-Qaeda members). The Predator had begun development in January 1994 as an advanced concept technology demonstration designed for reconnaissance, surveillance, and target acquisition. In October 2001, an undisclosed number of Predators, under the direction of the Central Intelligence Agency (CIA), were deployed to Afghanistan. Although initially used for reconnaissance, they were eventually modified to accommodate Hellfire rockets. These modified Predators were used extensively to destroy enemy targets. Following the successes of UAVs in Operation Enduring Freedom, the

DoD announced that it planned to spend $5 billion for research, development, and acquisition of UAVs.

UAVs and the Future

Although UAVs represent a potentially significant addition to the U.S. arsenal, there is mounting evidence that rogue states and international terrorist organizations are also interested in acquiring and using UAVs. With their ability to release an agent at the appropriate height for maximum effect, a UAV is an ideal delivery vehicle for chemical or biological weapons. In 1998 during Operation Desert Fox, the British military reported a missile attack on an Iraqi hangar and uncovered approximately twelve Iraqi UAVs modified with spray attachments and wing-mounted tanks capable of carrying 80 gallons of liquid anthrax. A British defense official dubbed these UAVs drones of death and speculated that under the right conditions, one would be capable of covering several city blocks with a deadly chemical cloud.

After the terrorist attacks on September 11, 2001, the U.S. government revealed that some al-Qaeda members had explored the possibility of learning to fly UAVs. Additionally, during Operation Enduring Freedom, U.S. forces discovered operation manuals for unmanned remote-controlled helicopters in an al-Qaeda safe house. There is a tendency to underestimate the potential threat that UAVs represent, as they fly relatively slowly and are vulnerable to air defense systems once such systems are alerted to the threat. But, it remains unclear how effective air defense systems are against UAVs, which constitute a relatively small and potentially stealthy target.

—William S. Clark

See also: Aerosol; Al-Qaeda; Bioterrorism; Iraq: Chemical and Biological Weapons Programs

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V

VACCINES

Vaccines, toxoids, and immunoglobulins (antibodies from blood preparations) can be used to protect or treat individuals exposed to biological warfare (BW) agents. Currently, few vaccines are approved for use in humans against potential BW agents.

As of this writing in 2004, the U.S. military continues a somewhat controversial anthrax vaccination program for active military personnel, and smallpox vaccine is also being administered to military servicepeople. The smallpox vaccine program also includes civilian first responders in the United States, but only a small percentage of civilian emergency workers participated in the program during 2003. Apart from these two vaccines, no other vaccines are routinely administered to protect military personnel against other BW agents, although it is possible that more will be added to the list of routine inoculations in the near future. Also available are botulinum toxoids (detoxified proteins used to generate an immune response) and an investigational new drug (IND) immunoglobulin for treatment of botulism, but these would only be used when an attack has already occurred or is nearly certain. As for the ten or so other potential BW threats (see Table V-1), vaccines are being researched and developed but will probably not see efficacy trials in humans for several years to come.

A preliminary list of the standard pathogens and toxins is rather daunting when one considers the possible BW agents that could pose a threat to civilian or military personnel (see Table V-1).

By the end of 2003, the United States had stockpiled sufficient smallpox vaccine for nearly all of its population. In the event of an attack using smallpox virus, the vaccine used to counter the disease can be effective if administered within two or three days of exposure. Among treatment modalities for the high-threat BW agents, however, smallpox vaccine is the exception. For other diseases, vaccines must be administered well before exposure to the pathogen or toxin (about 2 weeks in advance). When symptoms appear in a population, therefore, it will be too late to utilize most vaccines. The anthrax vaccine currently used in the United States for military personnel is effective against aerosolized

Table V-1: Vaccines Available in the United States against Major BW Threats

BW Agent Threat	*Disease Incubation Period*	*Vaccine Status (United States, as of 2002)*
Anthrax (*Bacillus anthracis*)	1–5 days	FDA-approved vaccine (U.S.)
Tularemia (*Francisella tularensis*)	2–10 days	Investigational New Drug (IND)
Plague (*Yersinia pestis*)	2–3 days	Not available in United States
Brucellosis (*Brucella* sp.)	5–60 days	None for human use
Q-fever (*Coxiella burnetii*)	10–40 days	Investigational New Drug (IND)
Smallpox	7–17 days	Wyeth (approved); other is IND
Hemorrhagic fevers (viral)	4–21 days	Investigational New Drug (IND)
Venezuelan equine encephalitis (VEE)	2–4 days	Available for certain serotypes
Botulinum toxin	1–5 days	Toxoid (pentavalent)
Staphylococcal enterotoxin B	1–6 hours	None available
Ricin (toxin)	3–24 hours	None available

Bacillus anthracis bacteria. Because anthrax tops the list of BW agent threats, the U.S. government decided to make it mandatory for active duty members of the U.S. military.

History of Vaccines and Warfare

The development of vaccines throughout modern history has often coincided with military operations. Although the recent threat of bioterrorism has triggered enormous research and development efforts in the United States to produce vaccines, immunization programs have for the most part emerged to counter naturally occurring disease threats in various parts of the globe.

Perhaps the first recorded use of preventative medicine in a military context occurred in the beginning of the Qing dynasty in China (ca. 1700 C.E.), when the emperor's armies faced smallpox from northern invaders. To accomplish this, variolation—the use of the smallpox virus—was introduced into military conscription. The practice of variolation that was later routinized in the Qing dynasty was basically a form of vaccination against smallpox. Variolation is said to have been used in Africa in ancient times, and it may have been practiced by Buddhist monks at the Mount E' Mei Temple in the Sichuan province of China sometime during the Renzong dynasty (1022–1063). These monks were said to have originally learned the procedure from the Tibetans, who in turn had been taught by Indians. By the 1500s, variolation was often mentioned in Chinese medical texts.

The Chinese method consisted of scraping the dried smallpox pustules from those who had become ill with the disease, pulverizing the crusts into a powder, and blowing the infectious material into the nasal passages of the noninfected. In Europe (as in Turkey), the process was one of scarification, that is, scratching the skin on the arm and applying the pulverized smallpox tissue. As one might expect, either route of inoculation was dangerous, for there was little guarantee that full-blown smallpox would not result. But in most cases, variolation caused a mild form of the disease but nothing more, affording protection from future exposures to the smallpox virus. Widespread use of variolation in China was not popular, by all accounts, and until the seventeenth century, the emperor's family did not see much need for it.

Seventeen years after the Manchurians conquered China, however, the Emperor Fulin (also referred to as Shizu) died from smallpox in 1661. In that same year, breaking tradition with previous Chinese defense policy, his brother, now the Kangxi emperor, decreed that his military carry out variolation for all troops. If true, this predates by more than 100 years General George Washington's order that Continental army soldiers undergo a similar procedure.

The British army had also adopted the practice of variolation in the early 1700s. Because many American colonists had themselves previously served in the British army, knowledge of the technique was widespread by the time of the American Revolution. A former British soldier himself, George Washington had more than a passing knowledge of smallpox, having survived the disease as a young man during a brief stay in Barbados. Around the time of the Revolution, smallpox was quite common in America, and smallpox was a constant problem for Continental army troops. General Washington had spent considerable time and effort emphasizing the importance of hygiene for his own army. In April 1775, he received intelligence that the British were making an attempt to use smallpox against the rebellion, and he concluded: "[T]he information that I received that the enemy intended Spreading the Small pox amongst us, I could not Suppose them Capable of—I now must give Some Credit to it, as it has made its appearance on Severall of those who Last Came out of Boston" [sic] (Bayne-Jones, p. 52).

In April 1776, Dr. John Morgan, who was physician in chief to the Continental army, urged that widespread variolation be conducted for the troops, and in 1777, Washington made it official:

> I have directed the Doctr. [Nathaniel] Bond, to prepare immediately for the inoculating this Quarter, keeping the matter as secret as possible, and request, that you will without delay inoculate all the Continental Troops that are in Philadelphia and those that shall come in, as fast as they arrive. . . . I would fain hope that they will soon be fit for duty, and that in a short space of time we shall have an Army not subject to this, the greatest of all calamities that can befall it, when taken in the natural way. (Bayne-Jones, p. 52)

Records from the routine variolation of Continental army soldiers showed that mortality due to the in-

Table V-2: Chronology of Selected Immunization Initiatives for Military Personnel

Country/Region	*Vaccine*	*Threat Mode(s)*
1661, China, Qing Dynasty	Variolation (smallpox)	Naturally occurring
1777, United States, American Revolutionary War	Variolation (smallpox)	Naturally occurring/possible BW sabotage
1899, Great Britain, Boer War in South Africa	Typhoid (Almroth Wright)	Naturally occurring
1938, Great Britain, World War II	Tetanus toxoid	Naturally occurring (war injuries)
Germany, World War II, Afrika Korps	Cholera, typhus	Naturally occurring
1942 (January), United States, World War II	Yellow fever	Biological warfare
1942–1943, Germany, Stalingrad front	Plague	Biological warfare (?)
1942, Soviet Union, Stalingrad front	Tularemia	Naturally occurring/biological warfare (?)
1943, United States, World War II	Influenza (type B)	Naturally occurring
1944, United States and Canada, World War II	Botulinum toxoid	Biological warfare
1945, United States, World War II (Army Air Force Technical School, experimental)	Pneumococcal (quadrivalent)	Naturally occurring
1945, United States, World War II (Okinawa)	Japanese B encephalitis vaccine	Naturally occurring
c. 1965–1975, United States, Vietnam War	Plague	Naturally occurring
1971–1999, United States, military recruits (to be resumed c. 2008)	Adenovirus (live type 4 and 7 vaccine)	Naturally occurring
1984, Soviet Union, resumption of vaccinating troops against smallpox following 5-year hiatus	Smallpox	Biological warfare
Until 1989, United States, part of routine military vaccinations; resumed 2002	Smallpox (*Vaccinia*)	Biological warfare
1991, United States, Gulf War	Anthrax	Biological warfare
1991, United Kingdom, Gulf War	Anthrax (U.K. version)	Biological warfare
1991, United States, Gulf War	Botulinum toxoid	Biological warfare
1997–present, United States	Anthrax	Biological warfare
1991–present, Israel	Smallpox (*Vaccinia*)	
2002–present, United States	Smallpox (*Vaccinia*)	Biological warfare

oculation procedure itself was approximately one in 300, compared to at least 16 percent for naturally acquired smallpox. Losses due to this disease dropped dramatically for the Continental army thereafter, no doubt influencing the outcome of the Revolutionary War.

Botulinum and D-Day

By World War II, incomplete but compelling intelligence indicated that the Axis powers were developing biological weapons. It turned out much later that the Allies underestimated Japanese biological weapons programs and that their threat perception of German BW was overblown. Still, by 1943, the United States, Great Britain, and Canada had instituted both defensive and offensive BW programs, starting with the development of vaccines.

By the time of the massive invasion of Normandy (D-Day) in 1944, the United States, Great Britain, and Canada had already considered the possible threat from German biological weapons. A year before D-Day, the American and Canadian intelligence services had reason to believe that Germany would use botulinum toxin against the Allies, possibly loaded on V-2 rockets to strike disembarking positions or used in some other fashion against the beach landing forces. Relying primarily upon the information provided by a German refugee scientist, Helmuth Simons, both Canada and the United States prepared large amounts of botulinum toxoid as a vaccine for the landing troops. Canada produced at least 25,000 doses of the toxoid, and the United States made enough (more than 1 million units) to inoculate at least 300,000 American troops if necessary. The latter was a formalin-denatured, alum-precipitated (the toxin was made non-toxic with formaldehyde solution, then brought out into extractable form) toxoid for type A botulism. (Botulinum type B toxoids were also under production, but these never made it to Europe.)

During the Normandy landing, however, none of these vaccines were used. Historical research by John Bryden and others showed that the higher echelon of Allied commanders was by that time reasonably secure in the knowledge that the German military had no immediate plans to use chemical or biological weapons. Because the British Ultra code decrypts were so strictly classified, however, security demanded that only the most highly ranked of the Allied leaders had a "need to know" this information. The scientists and their managers who were responsible for production of botulinum toxoid, therefore, were left unaware of this intelligence and continued their work until nearly war's end.

During Operations Desert Shield and Desert Storm during the Gulf War (1990–1991), 150,000 U.S. military personnel were given the anthrax vaccine. Due to limited quantities on hand, however, fewer of these (about 8,000) were able to receive a botulinum toxoid preparation. This pentavalent (protecting against five types of botulinum toxin) vaccine was prepared from *Clostridium botulinum* cultures (serotypes A through E) and had been previously used for hundreds of U.S. Army researchers since the 1950s. Although it was not entirely certain whether this would be effective against exposure to aerosolized botulinum toxin, a week into the air campaign against Iraq, the U.S. Food and Drug Administration (FDA) finally approved the safety of the botulinum toxoid for American troops.

During the Gulf War, the insufficient number of doses to inoculate everyone against anthrax and botulinum presented a moral dilemma for U.S. and Coalition military commanders: With a limited supply of both botulinum toxoid and anthrax vaccines, who should receive them? Some commanders clearly regretted that only partial vaccinations were performed and would rather have had the risk equally parceled out among all (i.e., they would rather have vaccinated no one than only some). It was finally decided, however, that some was better than none, and those troops and personnel stationed in areas more likely to be under a BW threat were given priority for inoculation. There is no evidence, however, that Saddam Hussein's military used biological weapons against Coalition forces.

At present, the U.S. military only vaccinates its personnel against two possible BW agents: *Bacillus anthracis* (anthrax) and smallpox. The justification for this ongoing immunization program is that foreign militaries and terrorist organizations such as al-Qaeda could weaponize these agents. Smallpox, although much less likely of a threat, would present such horrible consequences as a contagion that the U.S. government has decided to vaccinate active duty military personnel and civilian first responders.

It is difficult enough for militaries to conduct vaccination programs for soldiers against biological weapons. Governments face even greater challenges when it comes to vaccinating civilians against BW threat agents. Before measures are undertaken to immunize a population against a particular BW threat, one must balance the risks versus the benefits. In making a decision to vaccinate the general public against possible BW threats, one must know the relative safety of the vaccine and compare that to the projected risk from bioterrorism. Scientific studies can afford details as to the likely number of people who will suffer bad side effects from vaccines. However, we cannot predict with any accuracy the actual threat from BW agents. As a consequence, there is no current plan to vaccinate U.S. citizens in general against smallpox, anthrax, or any other BW threat.

—Eric A. Croddy

See also: Bioterrorism; Biological Terrorism: Early Warning via the Internet; Smallpox; Toxoids and Antitoxins; United States: Chemical and Biological Weapons Programs

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V-AGENTS

The name *V-agents* is a shortened form of "venomous" agents. The category includes those organophosphate (OP) compounds that share similar structural and toxic properties to those of the G-nerve agents but possess even higher toxicity. Included in this category are VX, the former Soviet "V-gas," and other relatively obscure analogs VG (Amiton), VM, VE, and VS. Only VX and the Soviet version of VX, however, have been weaponized.

The toxicity of VX via inhalation is three times that of sarin, and VX is 100–400 times as toxic as sarin when absorbed through the skin. Pure VX has no color, is odorless, and at room temperature is a free-flowing oily liquid. It has a boiling point of 298° C and a freezing point of minus 39° C. In cases of skin exposure, symptoms can appear 5–7 minutes following skin absorption.

As with other nerve agents, the toxic principle of the V-agents is the inhibition of the enzyme acetylcholinesterase (AChE), the key to normal nerve impulse transmission at the molecular level. The resulting increased levels of the neurotransmitter acetylcholine produce exaggerated levels of bodily secretions and muscular twitching, as well as pronounced effects on the cardiovascular and central nervous systems. Death from respiratory paralysis can occur as a consequence. Victims also are prone to asphyxiation due to excess mucous and salivary excretions from the upper respiratory tree. Without timely medical intervention and follow-up treatment, those who do survive exposure to large doses of nerve agents can suffer permanent neurological damage. This may be even more true in the case of the V-agents, as these are fat-soluble compounds and quite capable of passing through the fatty membrane that composes the blood-brain barrier.

Background

The German chemist Gerhard Schräder and his team first discovered the highly toxic OP compounds tabun and sarin in the late 1930s. Other formulas that had commercial applications as insecticides (particularly those that were safe to use near mammals) were patented at the end of World War II. Some of these were also developed for large-scale insecticide use, marketed under the names Dimefox (1940) and Parathion (1944).

Like the G-series nerve agents, the V-series of compounds was also discovered during insecticide research involving OP compounds. In a roundabout way, the discovery of VX—the most potent military nerve agent ever developed—had its start in the Korean War. In early 1951, U.S. Army hygienists noted strong resistance in lice to DDT when delousing North Korean prisoners and refugees. When DDT and other organochlorine-based insecticides began to lose their effectiveness, chemical firms such as Bayer and Imperial Chemical Industries sensed that the market was especially ripe for new and better replacements, including OP-based chemicals.

In 1952, Dr. Ranajit Ghosh of the British company Imperial Chemical Industries patented some novel OP compounds that would later form the basic structure for VX. (Reportedly, in his independent work, Lars-Erik Tammelin of the Swedish Institute of Defense Research also discovered this type of compound in 1952). Although Ghosh's goal was to develop safe and effective insecticides, one of his new inventions was found to be quite toxic to mammals as well. These toxic chemicals had no apparent commercial value, but it was thought that they possibly could be of interest to the military.

Noting its military significance for development as a nerve agent, the formula and sample of Ghosh's toxic OP compound were handed over to the defense laboratories of Porton Down in the United Kingdom. But during the 1950s, the British military had already decided to adopt one of the G-series nerve agents for use and was in the process of building a chemical arsenal consisting of either tabun (GA) or sarin (GB). The British government gave Ghosh's basic formula to the United States in 1953, and in 1955, Ghosh's chemicals were coded V agents due to their "venomous" nature.

After some structural changes to Ghosh's molecule were made at the U.S. Edgewood Arsenal laboratories, one analog was coded VX and standardized in the U.S. military in December 1957. In a U.S. Chemical Corps annual report, it was subsequently noted that "the reign of mustard gas, which has been called the King of Battle gases since it was first used in July 1917, will probably come to an end" (Smart, p. 49). This opinion was based on the fact that VX is a highly potent nerve agent that can act through the skin as well as by inhalation.

In 1960, a facility formerly known as the Dana Heavy Water Plant in Newport, Indiana, was converted to produce VX for the U.S. chemical weapons arsenal. Production of VX in the United States continued through the 1960s. In 1968, while training with a VX aerial munition near Dugway Proving Grounds, Utah, a U.S. military aircraft accidentally released about 20 pounds of VX in an open field. There were no human casualties, but at least 3,000 sheep died in this incident. After another accident in Okinawa involving nerve agent (sarin), on July 22, 1969, the U.S. Department of Defense formerly announced the accelerated removal of these agents from the Pacific theater.

Finally, in November 1969, President Nixon ended production of chemical warfare (CW) agents, following an earlier decision to renounce offensive biological warfare. In 2003, more than 1,200 tons of VX nerve agent remained stored at the Newport Chemical Activity in canisters. After numerous delays, destruction of VX nerve agent was scheduled to begin in late 2003 using a neutralization process involving sodium hydroxide. Political, environmental, and technical issues have delayed the destruction timetable into 2004.

VG (also known by its trade name, Amiton) is an odorless, oily liquid with a similar viscosity to that of motor oil. It is relatively persistent. Like other oils, VG is soluble in fat, and skin absorption of the liquid presents a significant hazard. VG is not as toxic as VX, but its high toxicological profile—and suitability for weaponization—forced its inclusion as a Schedule 2 toxic chemical in the Chemical Weapons Convention (CWC). It is described in the chemical literature as either being colorless or having a yellowish color (perhaps due to impurities), as well as being a low-viscosity liquid with moderate volatility, evaporating only in small amounts at room temperature.

—*Eric A. Croddy*

See also: Nerve Agents; Organophosphates; Parathion (Ethyl and Methyl); V-Agents

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VECTOR

In the context of infectious disease, a vector is an arthropodic agent that transmits bacterial, viral, parasitic, and, in some cases, fungal diseases to humans, animals, or plants. Lice, fleas, and mosquitoes have been the vectors most responsible for the spread of diseases such as typhus (*Rickettsia prowazekii*), bubonic plague (*Yersinia pestis*), and malaria (*Plasmodium falciparum*), respectively. In modern times, the controlling of vectors—chiefly through the efficient use of insecticides, draining of standing water, and other hygienic practices—has led to dramatic improvements in public health.

The spread of bubonic plague, a disease that reduced European populations by as much as one-third in the fourteenth century, begins with a reservoir of infectious bacteria carried in rodents. When a flea consumes a blood meal from a plague-infected rat, it has a good chance of consuming *Y. pestis* bacteria. This can lead to the formation of a fibrinous (solidified material that forms in response to inflammation) plug in the upper region of the flea's stomach (proventriculus), preventing the flea from being able to digest additional blood meals. Now starving, the flea may bite a number of different mammals in an effort to feed, including humans. When the fleas bite humans or any other mammals, they disgorge the infectious material into the wound, which can lead to the development of bubonic plague. The flea in this cycle typifies the role of the vector, and the rat is the epizootic pool of a pathogen (*Y. pestis* bacteria).

Such vectors were utilized in the Japanese biological weapons program conducted in China (1937–1943). The notorious Unit 731, led by Ishii Shiro, grew fleas in the laboratory and allowed them to feed upon plague-infected rats. Later, the fleas were collected and placed into specially designed porcelain bombs (the porcelain shell was broken when the bomb was thrown, releasing plague-infested fleas into the area). Some reports indicated that plague spread quickly following Japanese attacks using these bombs and following other attacks using plague bacteria. Plague, however, had already been endemic in China since 1894, so it is difficult to assess the effectiveness of these Japanese biological warfare operations. During wartime, it is also typical to expect large natural outbreaks of disease, making it more difficult to estimate with certainty the effectiveness of this flea-based biological weapon.

Conceivably, other diseases such as viral encephalitis (e.g., Venezuelan equine encephalitis and West Nile virus) could be spread by infecting animal hosts, harvesting mosquitoes that carry the virus, and releasing these insects upon densely populated areas. From the bioweaponeer's perspective, however, it is unclear how many infections among targeted populations would result, to what degree infections could be sustained, and whether or not the whole exercise would be worth the expenditure of time and resources. Furthermore, there is an arsenal of weapons that can be deployed against arthropods to quickly neutralize the threat of spreading the infection. Although environmental regulations generally restrict the wider use of insecticides, in event of an emergency—such as a large spike of West Nile infections in New York City—there is little doubt that local authorities would be able to saturate suspect areas with insecticides such as malathion. With such a response, the major threat from the disease would be largely mitigated. In a military setting, the use of insect repellents (particularly diethyl toluamide or DEET) and insect control with insecticides can likewise prevent the spread of vector-borne disease, whether these are natural or deliberately caused.

—Eric A. Croddy

See also: Biological Warfare; Plague

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VECTOR: STATE RESEARCH CENTER OF VIROLOGY AND BIOTECHNOLOGY

During the Soviet era, the State Research Center of Virology and Biotechnology (VECTOR) played a crucial role in the research and development of biological weapons. Although precise details are not known, it is likely that VECTOR participated in the experimental study of most, if not all, antihuman viral BW agents researched and developed for biological weapons, including highly infectious and virulent pathogens such as Marburg hemorrhagic fever. VECTOR also tested antiagricultural agents under the program code-named Ekologiya ("Ecology").

At its height of activity in the late 1980s, VECTOR had a staff of more than 4,500. Following the fall of the Soviet Union (and with it, the end of the Soviet offensive biological warfare program), the total number of workers at VECTOR in January 2003 stood at 1,147, most of these being researchers. Today, the State Research Center of Virology and Biotechnology is one of Russia's largest research and production facilities. It carries out basic and applied research in the natural sciences, and it develops and produces therapeutic, preventive, and diagnostic products.

Background

VECTOR had its origins in the 1974 establishment of the All-Union Research Institute of Molecular Biology (Order No. 1683 of the Central Administrative Board of the Microbiological Industry with the Council of Ministers, August 2, 1974). The main purpose of VECTOR was to provide scientific base technology and infrastructure to study pathogenic viruses, while exploiting advanced gene-based techniques to produce vaccines and clinical diagnostics. Officially, VECTOR was created following a decree by the Soviet BW organization Glavmikrobioprom in March 1985, but its essential elements as a research facility for studying dangerous pathogens had been built by 1980.

VECTOR still houses a number of smaller institutes in its unique facility. VECTOR can undertake advanced research on extremely dangerous pathogens and has one of the few biosafety level 4 laboratories in the world. Another important aspect of the facilities at VECTOR is the ability to breed and care for experimental animals, including primates, for laboratory research.

*VECTOR's Smallpox Virus (*Variola Major*) Collection*

Located in Koltsovo (outside Novosibirsk, Siberia), VECTOR is a massive complex consisting of some

100 buildings, occupying more than 200,000 square meters of working space. In addition to a large pathogenic microbe strain library housing more than 15,000 viruses (including Ebola and Marburg hemorrhagic fevers), VECTOR is one of two facilities that possesses smallpox virus (the other is in the United States at the Centers for Disease Control and Prevention, Atlanta, Georgia). Smallpox (*Variola major*) viruses had been collected in the former Soviet Union and stored since the 1950s at the Mechnikov Research Institute of Vaccines and Sera in Moscow. Later, about 120 strains were moved to VECTOR, where they are currently stored. Most are frozen, but twenty-four strains are kept in freeze-dried (lyophilized) storage. Today, VECTOR consists of the following research organizations:

- Scientific Research Institute of Molecular Biology
- Scientific Research Institute of Aerobiology
- Scientific Research Institute of Bio-Engineering
- Scientific Research Institute of Cell Cultures
- Scientific Research Institute of Microorganism Culture Collections
- Scientific Research, Design, and Technological Institute of Biologically Active Substances
- Vector-Farm Production and Marketing Firm
- Experimental Production Agricultural Enterprise

Among the many research projects that have been conducted at VECTOR is the complete genetic sequencing of *Variola major* (India strain) smallpox virus. Due to concerns about the security of one of the world's only two official repositories of the smallpox virus, the United States government conducted cooperative programs during the late 1990s to help secure VECTOR's collection from potential theft by terrorists, rogue states, or even insiders. Much of the funding for those efforts, including financing of peaceful research to keep former Soviet BW scientists gainfully employed, has come from the U.S. Cooperative Threat Reduction BioSafety Program.

After the fall of the Soviet Union, the full extent of the Soviet BW program became better known to the West, especially following the revelations of defectors Vladimir Pasechnik and Ken Alibek (Kanatjan Alibekov). With no more funds from the Soviet military to maintain buildings or pay scientists their living wages, the proliferation threat from former Soviet BW scientists selling their knowledge to foreign governments became an acute concern for security planners in the United States and other Western governments. Stemming a so-called brain drain became a new priority among nonproliferation activities. A number of funding programs, including those from the U.S. Congressional Defense Against Weapons of Mass Destruction Act of 1996 (PL 104-201, September 23, 1996; also known as the Nunn-Lugar-Domenici Act), also addressed the BW problem in former Soviet BW institutes.

With funding provided from the International Scientific Technical Center (ISTC) in Moscow, as well as from a number of other technical partnerships with U.S. and other foreign-based governments and biotech firms, VECTOR continues to engage in a variety of research projects in infectious disease and molecular biology. VECTOR has sequenced the complete genomes of, among other viruses, the causative agent of Venezuelan equine encephalitis, tick-borne encephalitis, and Marburg and Ebola viruses. Since 1995, VECTOR has engaged many other important studies, including the following:

- Organization of production of inactivated vaccine against hepatitis A
- Development of the live cultural influenza vaccine
- Development of the production technology for immunoenzyme diagnostic kit (using enzymes for clinical tests) for the parasite toxoplasmosis using purified proteins of *Toxoplasma gondii*
- Solving the problem of Y2K to provide reliable control of the main biosafety engineering system in the VECTOR building
- Study of the genomic structure of Crimean-Congo hemorrhagic fever virus isolates (specific types found) circulating in the southern regions of NIS (Newly Independent States) countries
- Study of the genetic and antigenic (genetic makeup and immunology) diversity of

hantaviruses (caused by Bunyaviridae type viruses) in the Asian part of Russia
- Study of monkey pox virus genome
- Development of the microencapsulated form of the live measles vaccine

Additionally, VECTOR has partnered with the U.S. Defense Advanced Research Project Agency to conduct the following research projects:

- Experimental evaluation of the efficiency of inactivating and protective preparations against viruses pathogenic for humans
- Study of the possibility of intranasal immunization against tick-borne encephalitis by recombinant (the use of genetic engineering) viral gene vaccines
- Development of new therapeutic preparation based on the orthopoxviral (smallpox type) protein binding human tumor necrosis factor (TNF, disease protein marker)
- Elaboration of the methods of predicting humans' susceptibility to and efficacy of protective preparations under the conditions of viral aerogenic (caused by inhalation) infection

VECTOR has also participated in studying other pathogens, including the parasite *Toxoplasma gondii* (the causative agent of toxoplasmosis), which can cause devastating infections in humans, especially in the prenatal stages and in those individuals with compromised immune systems.

—Eric A. Croddy

See also: Biopreparat; Russia: Chemical and Biological Weapons Programs

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VESICANTS

Vesicants (or blister agents) are chemicals that attack the skin. True vesicants such as mustard and lewisite cause extreme irritation of the skin, eyes, and, most critically, the upper respiratory tract. The cell-killing ability of these compounds results in the formation of blisters that start as small vesicles (thus the name) on the skin. Vesicants used as CW agents generally take the form of an oily liquid, with varying degrees of volatility (propensity to evaporate).

Mustard has true cell-killing ability, and damages genetic material in cells by cross-linking DNA. Thus, long-term exposure will increase the chance for cancerous growths, although single exposures (even large doses) are not expected to significantly increase the risk of cancer. The greatest danger from extensive mustard exposure is inhalation of vapors. Due to mustard's ability to kill tissue, dead layers of cells lining the airways flake off, forming a false membrane. These cells can fall into the smaller airway tubes, blocking the egress and ingress of air, causing collapse of the lungs.

Sulfur mustard has been used in conflicts since its entry on the battlefield in World War I and was used extensively by Iraq against Iranian forces during the 1980–1988 Gulf War. In contrast, nitrogen mustards and lewisite have rarely been used in combat. Sulfur mustard (and probably nitrogen mustard) affect tissues in a typical delayed fashion, creating painful irritation to exposed surfaces (especially the eyes) after some delay (one to two hours or more). Lewisite is immediately irritating to the ear, nose, and throat, with painful irritation of the skin also occurring much faster (about 15 minutes following contact).

The chemical warfare (CW) agent phosgene oxime (not to be confused with the World War I-era gas phosgene) is usually included in discussions concerning vesicants. Phosgene oxime, however, acts in a different manner on the skin and is immediately painful. In contrast to other vesicants, phosgene oxime is a solid in its pure state and could be delivered as a pulverized dust or in an aerosol. Phosgene oxime could also be delivered as a liquid in its impure state or in a solvent. The action of phosgene oxime has been compared to the type of stinging injury caused by the nettle, thus it is sometimes called nettle gas. There are actually a number of different oximes that could be utilized as CW agents; all are extremely irritating not only to the skin, but also to the respiratory tract.

During the first 2 years of World War I, the arsenal of CW agents available to the belligerents primarily consisted of volatile substances, that is, true "gas warfare." The use of toxic compounds that evaporated quickly—chlorine, phosgene, and diphosgene, for example—helped to create effective concentrations of toxic chemicals. Because these were vapors and gases, the only route for intoxication was via inhalation. In the latter stages of the war, however, both sides developed effective means to protect troops' respiratory systems from chemical injury by using protective masks. In response, the German military put great effort into the production of diphenylcyanoarsine (DC), a so-called arsenical that was irritating in very small concentrations. One of the strategies for using this substance was to render gas masks ineffective by delivering DC in a fine aerosol, producing very small particles that would penetrate the filters used in protective masks at the time. This would force the removal of the mask, thereby making the enemy vulnerable to further assault with other toxic agents. It proved difficult, however, to deliver these sternutators, or "sneeze" gases, in particles small enough to achieve this effect.

Mustards

Because enemy defensive masks could not be defeated with arsenical compounds in World War I, the German military command investigated other alternatives. Mustard proved to be the answer. Sulfur mustard had been known since the 1880s as a very toxic compound to exposed skin surfaces.

Although often described as a gas, sulfur mustard (code-named H, or HD for distilled mustard, in the North Atlantic Treaty Organization terminology) is in fact an oily liquid. Sulfur mustard can cause injury through vapors, inhalation of aerosols, contact with contaminated surfaces, or a combination of all of these. Mustard is fat soluble and able to penetrate clothing (including some forms of rubber), making full-body protection necessary. The toxicological effects of mustard are insidious, causing blisters on the skin, temporary blindness (sometimes with permanent loss of vision), and life-threatening damage to the upper airways. Such symptoms occur within hours of exposure. Not only the liquid itself, but also the vapors from the liquid present a hazard. For example, after 1 hour, redness and inflammation of the skin would follow exposure to as little as 0.001 milligram of mustard per liter of air.

Mustard is particularly insidious because the effects are delayed by at least 1–2 hours. Thus, victims of mustard exposure could receive lethal doses of mustard and not realize it until it was too late to seek treatment. Vesicants, including mustard, have a particular affinity for thin layers of skin, including those under the arms and in the groin. Following such injury, mobility of soldiers is significantly reduced, and function is further degraded by severe pain from eye irritation. Although most victims fully recover from such injuries, blindness can occur in cases of large doses, and infections can set in following blister formation. At present, there is no effective treatment for mustard exposure. Decontamination of affected areas and supportive care are the only options at present.

Mustard freezes at a relatively high temperature. Therefore, at temperatures near its freezing point, it requires some solvent to keep it liquid. During World War II, Allied researchers investigated the mixture of mustard with diisopropyl fluorophosphate (DFP). This concoction not only lowered the freezing temperature of mustard, but also added a nerve agent component to the mix.

Since it was first used in World War I, and particularly during the Iran-Iraq War (1980–1988), mustard has proven mostly to be a defensive weapon. In both conflicts mentioned above, mustard was intended to help prevent military units from being overrun by enemy forces. For example, in 1917, Germany's main concern was to protect against a final offensive push by Allied forces, and Iraqi forces were being harried by sheer numbers of fanatical Iranian volunteers who feared neither bullets nor land mines. Before the invention of the nerve agents, mustard was considered king of the CW agents due to its ability to cause many casualties, especially via secondary contamination of ground, equipment, off-gassing from clothes and shoes, etc.

Even today, mustard remains one of the top CW threat agents, not just because of its versatility as a weapon, but because it is relatively inexpensive and easy to make. It is therefore not surprising that Iraq made extensive use of mustard against both Iranian forces and Kurdish elements during the Iran-Iraq War. Although Western countries (led by the United States) cut off exports of mustard precursors to Iraq and Iran in 1984, Iraq was able, by adapting its own petroleum distillation capabilities, to produce sulfur mustard indigenously.

Nitrogen mustards were under development by about 1935. The different series of nitrogen mustards were code-named in the U.S. military as HN-1, HN-2, HN-3, and HN-4, but these did not find favor in the United States as a weapon. Germany, however, stockpiled significant quantities (2,000 tons) during World War II. Nitrogen mustards affect the skin and membranes of the eyes, nose, and respiratory tree in similar ways to sulfur mustard. Traditionally, nitrogen mustards have been described as having a fishy odor. Although nitrogen mustard has been little used in warfare, it was previously one of the most effective chemotherapeutic agents discovered for treating cancer. Now, however, nitrogen mustard (Mustargen) has been largely replaced by less toxic and more effective alternatives.

Lewisite

Another vesicant that has not seen much use in battle, aside from some unconfirmed use by the Japanese against China during World War II, is lewisite (L). An arsenical, lewisite was invented in 1917 by the American chemist Winford Lee Lewis, from whom it received its name. At the same time, a German chemist (Heinrich Wieland) also researched this chemical, but for reasons still uncertain rejected it for further development as a weapon. Lewisite was stockpiled by Germany, the Soviet Union, and the United States during World War II. Some of the larger stocks of mustard-lewisite mixtures include those in the former Soviet chemical stockpile. (Abandoned chemical weapons in China left over from invading Japanese forces in World War II also contained mustard-lewisite mixtures.)

Lewisite offered advantages over other vesicants: it could be used in much colder temperatures than mustard and still remain liquid. Unlike mustard, the effects from lewisite are not as delayed; lewisite forms highly irritating vapors almost immediately. Redness and blistering of the skin follow, similar to the effects of mustard. Lewisite reportedly has an odor resembling that of geraniums. Lewisite has traditionally had an antidote in the form of British Anti-Lewisite (BAL), a mercaptan (sulfur containing chemical that can attach to heavy metals) compound used to scavenge for arsenic. Still, it is unclear whether this or other treatments are very effective.

Vesicants could be delivered in the standard artillery shells designed for chemical ordnance, or from cannons, artillery rockets, and larger rocket warheads. Although vesicants can be effective in any form of assault, their primary advantages (as described in Soviet military doctrine) have been in terms of denying enemy access to particular areas and contaminating logistical targets, causing the enemy to have to move around contaminated areas or suffer casualties. Contamination would also require time-consuming decontaminating efforts to remediate airfields, railway centers, and port facilities.

Technical Details

The production of sulfur mustard (and, to a lesser degree, nitrogen mustards), lewisite, and phosgene oxime is rather simple, but overall their toxicities are much less than those of the nerve agents. Today, militaries—if they desired to obtain an offensive CW capability—might choose mustard and lewisite because they are persistent (remain hazardous in the environment for a long time) and highly effective casualty agents. Terrorists, on the other hand, would probably find these agents less appealing because they are hardly the most toxic, and because they pose significant challenges to produce in large quantities. Some countries that have great difficulty in producing even basic chemicals, such as North Korea, may look to vesicants to maintain a nominal CW capability. Developing countries such as China and India, on the other hand, have the ability to produce most, if not all, known CW agents, including the much more toxic nerve agents such as sarin and VX.

The vesicants are prohibited by the 1993 Chemical Weapons Convention (CWC). Their precursors, such as thiodiglycol (for mustard) and arsenic trichloride (for lewisite), are also controlled under the CWC schedules.

—Eric A. Croddy

See also: Arsenicals; Mustard (Sulfur and Nitrogen); Phosgene Oxime (CX, Dichloroform Oxine)

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VIBRIO CHOLERAE
See Cholera

VIETNAM WAR

The term *Vietnam War* is often used to refer to U.S. military and diplomatic involvement in a series of wars fought in French Indochina from 1946–1975. Chemical agents were used in these conflicts, and the use of nuclear weapons always loomed on the horizon.

Historical Background

Starting in 1847, the land that is modern-day Vietnam was colonized by France. From 1940 to 1945, Japan added Indochina to its so-called coprosperity sphere. After Japan's surrender from World War II in August 1945, Vietnamese nationalists, led by Ho Chi Minh, launched the "August Revolution," proclaiming an independent state. France reasserted its claim to Indochina and by the end of 1945 had defeated Ho's Viet Minh forces in the southern provinces. In November 1946, the French governor general proclaimed an independent Republic of Cochin China in the south, leading to the First Indochina War, which lasted until French forces pulled out of the region in July 1954 following their defeat at Dien Bien Phu. The resulting Geneva Accords divided Vietnam at the seventeenth parallel, with national elections slated for 1956 to determine the government of a unified state including the north and south. This was not to be, as many fled the north to the south, and the latter part of the country proved resistant to the idea of Ho Chi Minh controlling all of Vietnam.

Fearing the likely rise of a communist government in the area, U.S. president Dwight Eisenhower began open support for the newly created government (1955) of the Republic of Vietnam in the south, led by Ngo Dinh Diem, a staunch anticommunist. A guerrilla-style war between the American-supported South Vietnam gradually became more intense as it could not reconcile with the northern communist regime. U.S. involvement in the conflict was gradual at first, with soldiers relegated to advisory roles until August 4, 1964, when the Gulf of Tonkin incident expedited heightened U.S. military involvement. In this instance, the United States claimed North Vietnamese torpedo boats attacked the U.S. Destroyer *Maddox*. President Lyndon Johnson ordered air strikes on North Vietnamese targets the same evening, and Congress supported this action with the Gulf of Tonkin Resolution. The wording if not the spirit of the resolution gave President Johnson more latitude to conduct offensive military operations in Vietnam, which then led to a dramatic escalation of U.S. military involvement in the war—including a massive bombing campaign against North Vietnam and the introduction of American combat forces on the ground. Despite a successful U.S. counterattack, the strong showing of the opposition in the 1968 Têt Offensive started the process of slow U.S. disengagement from the conflict.

A third phase of the war, this time involving just the Vietnamese, continued until Communist forces achieved victory in April 1975. In 1976, North and South Vietnam were officially reunited and became the Socialist Republic of Vietnam.

Chemical Weapons Use in Vietnam

The U.S. military used a chemical incendiary weapon called napalm during the war. U.S. forces also made extensive use of herbicides, most (in)famously Agent Orange, during Operation Ranch Hand from 1961 through 1970 to deny cover and concealment to the enemy and to damage food crops that were sustaining insurgent forces.

Napalm-B, used by the United States during this campaign, consisted of 50 percent polystyrene thickener, 25 percent benzene, and 25 percent gasoline. It was dropped from the air. Napalm was used on roughly 10 percent of all U.S. bomber missions during the conflict. This jellied gasoline mixture is virtually impossible to remove, and it kills those caught in the open by a combination of carbon monoxide asphyxiation and burning. After being ignited with phosphorus, napalmt burns at 850° centigrade for up to 15 minutes.

Nearly 19 million gallons of herbicide were used by the U.S. military in Vietnam between 1961 and 1970. Almost all of this herbicide was delivered using modified C-123 cargo aircraft. More localized application was accomplished using helicopters, towed vehicles, and backpacks. The optimal applica-

The U.S. Air Force used large quantities of Agent Orange and other herbicides during the Vietnam War. (Bettmann/Corbis)

tion rate was 3 gallons per acre. More than thirty herbicides were tested or used in Vietnam, six of which were given code names based on the colored bands on their 55-gallon storage drums. All were mixed with petroleum products to add stickiness for application. Agents Purple, Pink, and Green were used from 1962 to 1964 as defoliants. They contained significant levels of dioxin, which was later found to be highly toxic to humans.

Agent Orange was used extensively from 1965 through 1970. Although less potent than Purple, Pink, and Green, Agent Orange's widespread use made it the most notorious herbicide used in the conflict. A series of lawsuits by veterans of the war culminated in an out-of-court settlement in 1984 with the manufacturer of Agent Orange, Dow Chemical Company, which established a $180 million trust fund for individuals who claimed to have been sickened by exposure to the chemical. In 1992, the U.S. Centers for Disease Control and Department of Defense officially acknowledged Agent Orange's linkage to a wide variety of diseases, including Hodgkin's disease, Non-Hodgkin's lymphoma, and birth defects. However, the levels of dioxin required to cause disease in humans have not been well established.

Biological Programs during the War

The United States maintained a large biological weapons stockpile during the war but did not employ any of the weapons in combat. The U.S. stockpile included two lethal microbial agents (anthrax and tularemia bacteria); three incapacitating microbial agents (brucellosis bacteria, Q-fever rickettsiae, and Venezuelan equine encephalitis virus); one lethal toxin (botulinum); and one incapacitating toxin (staphylococcus enterotoxin B). Large volumes of these agents were manufactured and poured into cluster bomblets, spray tanks, and assorted other munitions, which were stored at Pine Bluff Arsenal in refrigerated bunkers and vans. President Nixon renounced the use of biological agents in a speech on November 25, 1969, and the U.S. stockpile was destroyed over the next 3 years, although research and development on defenses against biological attack continued.

Nuclear Considerations

Nuclear weapons were never used in the war, but the United States had a substantial nuclear arsenal. Although the use of these weapons was never imminent, there was support for limited nuclear strikes by some in the United States. Admiral Arthur Radford, chairman of the U.S. Joint Chiefs of Staff, and Air Force Chief of Staff Nathan Twining proposed using nuclear weapons to prevent the fall of Dien Bien Phu in 1954. The Eisenhower administration rejected this idea.

Later, during the U.S. phase of the war, retired General Curtis LeMay, who had commanded the U.S. Strategic Air Command, suggested that North Vietnam be bombed "back into the stone age." Senator Barry Goldwater, the Republican nominee for president in 1964, appeared on ABC's *Issues and Answers* program in May 1963 and stated, "defoliation of the forests by low-yield atomic weapons could well be done." Members of the Johnson administration were also concerned that Chinese intervention in the Vietnam War could prompt a large nuclear exchange in southeast Asia. At one point, the Nixon administration also escalated the nuclear alert levels of U.S. forces in a series of moves designed to make the Viet Cong and the Soviets believe that the United States was considering the nuclear option, hoping that this would give added leverage in negotiations to end the war.

—*James Joyner*

See also: Agent Orange; Napalm; Riot Control Agents

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VINCENNITE (HYDROGEN CYANIDE)

Vincennite is a French term for a cyanide-based weapon that was devised during World War I. It contained about 50 percent hydrogen cyanide (HCN), 30 percent arsenic (III) chloride, 15 percent tin (IV) chloride, and 5 percent trichloromethane, with HCN forming the "active ingredient" in this mixture. Throughout World War I, the other militaries had found HCN too difficult in terms of delivery as a weapon. Undaunted by the challenge, French military chemists devised a scheme using concoctions like vincennite and manguinite to work around the technically challenging issues posed by HCN when used alone—chiefly its high volatility and instability. Throughout World War I, the British military experimented with its own version of vincennite, but Germany did not pursue it beyond laboratory experiments. Despite the efforts by the French to weaponize HCN with various combinations of other chemicals, vincennite was ineffective as a war gas.

Background

By the end of 1915, the French military had filled significant numbers of "Special Shell 4" with HCN, but held back from using these due to the Hague Convention proscribing the offensive use of chemical artillery rounds. Under attack from German chemical shells in 1916, however, this consideration was made moot, and the French fired the first vincennite projectiles against German troops at Somme on July 1 that year. It is not known what, if any, casualties resulted from this chemical assault. The French might have used this as a means to break Germany's gas masks, which were thought to be effective only against chemicals such as phosgene. Having learned of French intentions to employ HCN a week prior to its introduction at Somme, however, Germany had prepared its troops with gas mask canisters augmented with silver oxide as a chemical barrier.

In addition to the extremely high volatility of HCN, the major technical hurdle involved in its use is its propensity to decompose in a violent polymerization (in a chain) reaction. Stannic chloride was used as a means to prevent HCN from evaporating too quickly. To stabilize HCN, chloroform was used to prevent it from polymerizing. Later, arsenic trichloride and other compounds were used in another concoction called manguinite, which was no more effective as a war gas than vincennite.

The failure of vincennite and other schemes to deliver this form of cyanide led most militaries to abandon HCN-based munitions, pursuing instead the development of cyanogen chloride. Intelligence gathered by Germany following World War II, however, indicated that the Soviet Union did not give up on HCN. According to Walter Hirsch, formerly with the German military intelligence apparatus, the Soviet Union began research into HCN weapons design in 1931, considering the chemical as "one of the most effective war gases for a surprise attack and destruction of living targets." The Soviets also employed stabilizers such as strong acids and metallic chlorides to create an effective HCN weapon. The disposition of these mixtures is not known, but it is presumed that they have long been discarded.

—Eric A. Croddy

See also: Blood Agents; World War I

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VX NERVE AGENT

See V-Agents

W

WETEYE BOMB

The Weteye chemical munition was a unitary nerve agent bomb used for sarin, formerly held in the U.S. chemical weapons stockpile. Coded the MK-116, the Weteye aerial bomb weighed approximately 240 kilograms and held about 160 kg of sarin nerve agent. Developed for the U.S. Navy in the 1960s, the Weteye was so named because the munition had a liquid nerve agent fill—hence the "wet"—and a camera-based guidance system—hence the eye.

Separated by perforated baffles, the inside was divided into three sections. The bomb itself was made of a thin aluminum alloy, with spring-loaded fins that would extend after the bomb's release from bomber aircraft. After the bomb was dropped, the fuse was armed. An explosive charge (composition B) would then break open the bomb's fuselage and spread sarin as an aerosol over the intended target.

In 1969, Weteye munitions were filled and stored at Rocky Mountain Arsenal, Colorado. The Weteye bombs were stored and shipped in MK 398 containers. All sarin bombs were neutralized at Rocky Mountain Arsenal in 1977, except for 900 Weteyes. These were then moved to the Deseret Chemical Depot in Utah, where they were destroyed pursuant to the U.S. ratification of the 1993 Chemical Weapons Convention. During the destruction process, some munitions were found to leak, and high levels of mercury were also discovered. Other factors—such as the potential for the aluminum casing to explode while inside the decontamination furnace—required special handling for this bomb's demilitarization. These factors made the final disposition of the Weteye bombs especially complicated for both political and technical reasons.

—Eric A. Croddy

See also: Binary Chemical Munitions; Difluor (DF, Difluoromethylphosphonate); Nerve Agents

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WORLD TRADE CENTER ATTACK (1993)

On February 26, 1993, a small group of men from the Middle East parked a rental van packed with 1,500 pounds of urea-nitrate explosive in the basement of the World Trade Center (WTC) in New York. There they detonated a bomb that killed 6 people and wounded 1,042. The destruction was not as great as the terrorists had hoped, or as others would later achieve against the same structure in September 2001, yet some reports suggested the involvement of chemical weapons in this attack. These accounts suggesting that chemical weapons were involved in the 1993 WTC attack are, however, most likely apocryphal.

Most members of the ad hoc group of perpetrators were inexperienced terrorists, at least in comparison to their mysterious and charismatic leader, Ramzi Yousef, who was linked with Islamic extremists (including Osama bin Laden) and the Iraqi government, though he likely belonged to neither group. Nonetheless, within 6 months, this small group succeeded in planning the attack, acquiring the necessary chemicals for the conventional explosive, and assembling a large, sophisticated explosive in a small apartment in Jersey City, NJ. Several of the conspirators were arrested shortly after the attack, but Yousef escaped to continue his terrorist career. He remained at large until he was captured on February 8, 1995.

Allegations that the WTC attack involved chemical weapons stem from comments made on May 24, 1994 by Judge Kevin Duffy during the sentencing of four of the perpetrators. Judge Duffy stated that the bombers had incorporated sodium cyanide into the bomb, intent on generating lethal levels of hydrogen cyanide gas to kill everyone in one of the towers. According to Duffy, the cyanide fortunately burned instead of vaporizing. Moreover, he asserted that many of the victims "had their lungs permanently scarred" by the burning cyanide. The judge's comments seem to be the source of subsequent reports of CW agents being used in the attack.

Although Yousef was an innovative and skilful bomb maker—he had a degree in electrical engineering and had received training in Afghan terrorist camps—it is unclear whether he had the technical capability to cause a large-scale release of hydrogen cyanide. However, his primary assistant in making the WTC bomb, Nidal Ayyad, was a chemical engineer, and together, they may have possessed the requisite skills to liberate hydrogen cyanide in an explosion.

Yousef, motivated by an intense hatred of the United States and Israel and driven by a need for self-aggrandizement, tried to kill as many people as possible by bringing down the WTC. He would have had no qualms about using CW to cause mass casualties. He certainly considered using chemical weapons in other attacks. In 1994 and 1995, Yousef had drafted letters threatening to use "chemicals and poison gas" unless authorities in the Philippines released a captured accomplice. He also reportedly contemplated attacking the Central Intelligence Agency with a chemical weapon-laden plane. Yousef admitted after his capture that he would have included sodium cyanide in the bomb, but claimed that he did not have enough money to do so.

The only physical evidence of chemical weapon use in the attack was a single, sealed bottle of aqueous sodium cyanide found with Yousef's fingerprints in a storage locker where the group stored its chemicals.

The heavily contaminated bomb site yielded no forensic traces indicating that the device had contained cyanide. A technical analysis of the amount of chemicals needed and conditions required to create hydrogen cyanide does not support Judge Duffy's conclusion, especially as the purchase of large quantities of sodium cyanide would likely have attracted attention, and as no significant cyanide repository connected to the group was ever found. The possibility of producing cyanide gas was, however, discussed during the 1994 trial, and this may have been the source of the judge's assertions about chemical weapons.

Although Yousef clearly had the motivation, and perhaps the technical capability, to cause the release of poison gas, his own admissions of financial limitations and a lack of forensic evidence make the presence of chemical weapons in the 1993 WTC bombing extremely unlikely.

—*Gary Ackerman*

See also: Al-Qaeda; Terrorism with CBRN Weapons

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WORLD WAR I

More than 8.5 million people were killed and more than 21 million were injured during World War I, which lasted for 4 years (1914–1918). World War I erupted at a time when advances in modern technology and logistics (such as railroads) created a synergistic effect, leading to mass human carnage. The use of a relatively new invention, the machine gun, and the ability to transport thousands of soldiers to the front contributed heavily to the deaths of millions in World War I. Although World War I is remembered for the advent of modern "gas warfare," bullets, bombs, and shells were responsible for most of the deaths during the war.

Before Germany resorted to using chlorine gas to break the Allied trenches in April 1915, fatalities on all sides had been averaging 150,000 dead every month. In only one day at the Somme (July 1, 1916), British casualties alone amounted to 57,470, and about 20,000 of these individuals died. Nearly all of these casualties were the result of conventional weapons. Although it is true that the use of gas in the Great War made an indelible mark upon postwar remembrances, the actual impact of chemical warfare (CW) was not very numerically significant. Throughout all of World War I, chemical weapons were the cause of less than 4 percent of the total casualties. Furthermore, the death rate from chemical injuries in World War I ran about 3 percent.

Much less is known about the role of biological warfare (BW) in World War I. The German agent

Most of these WWI British soldiers who were blinded by mustard eventually returned to active duty. (Bettmann/Corbis)

Anton Dilger might have managed to infect a number of pack animals that were to be used by the Allies by using cultured pathogens, but these unconventional attacks had no appreciable effect on the course of the war.

Gas Warfare

The first use of chemical weapons in World War I—Germany's chlorine cylinder attack on April 22, 1915 at Ypres, Belgium—caused at least 800 Allied deaths that day. It also required a massive effort for the Germans to haul (in the last stages of preparation by hand) some 6,000 chlorine gas cylinders to the front, all the while under observation by Allied forces. Contemporary observers (almost always French or British) claimed that the first major chemical attack at Ypres resulted in 5,000 deaths, but this is not supported by the evidence. A month later, however, Germany used chlorine gas (12,000 steel cylinders) against Russian troops along the Bzura-Ravka River to even greater effect, killing some 6,000 and injuring 3,100. In neither of these instances, however, did the use of chemical weapons change the outcome of the campaign. In the case of the April 1915 chlorine attack at Ypres, for example, Germany was not prepared to capitalize on the temporary break in the Allied lines.

Still, because gas warfare represented the dark side of modernity—and along with it, a cruel application for warfare—memories of World War I usually conjure up images of chemical weapons. The literature and subsequent images of gas warfare are indeed haunting. The Reverend O. S. Watkins wrote the following after the first major chlorine attack at Ypres, Belgium, on April 22, 1915:

> 'The French have broken,' we exclaimed. We hardly believed our words . . . . The story they told we could not believe; we put it down to their terror-stricken imaginings—a greenish-grey cloud had swept down upon them, turning yellow as it traveled over the country, blasting everything it touched, shriveling up the vegetation. No human courage could face such a peril. Then

> there staggered into our midst French soldiers, blinded, coughing, chests heaving, faces an ugly purple color—lips speechless with agony, and behind them, in the gas-choked trenches, we learned that they had left hundreds of dead and dying compadres. The impossible was only too true. It was the most fiendish, wicked thing I have ever seen. (Fries, p. 11)

The introduction of CW in World War I was actually more the result of desperation than evil genius. The father of modern CW, the German chemist Fritz Haber, himself admitted that he did not anticipate that the war would last much more than a year, and he certainly could not have foreseen the stalemated trench fortifications that would soon delineate the front. In northern France, Germany built up trenches near the Aisne River in September 1914. By year's end, the earthen fortifications stretched from Switzerland to the North Sea (about 475 miles). The extensive use of machine guns, as well as the improved accuracy in rifles, made offensive frontal assaults against these defended positions suicidal.

To turn the momentum in Germany's favor and to bring the war to an early conclusion, Haber directed the first use of chemicals (chlorine gas) for an attack at Ypres. This was the same site of the *Kindermord bei Ypren*—the massacre of the innocents at the battlefield in Ypres, Belgium—that occurred in November 1914. This horrendous skirmish made it clear early in the war that this world conflict would be one of "attrition, mass death and of receding hope of victory" (Keegan, p. 133). The April 1915 gas attack was (on a tactical level at least) a success, in that German troops were able to advance to where the chlorine cut a swath through Allied defenses, in this case comprised mostly of Algerian and Canadian troops. But Germany was not prepared with adequate numbers and materiel in reserve to exploit the temporary break in the Allied lines.

Momentarily shocked and staggered by Germany's use of chlorine at Ypres, the Allies created their own chemical munitions to respond in kind. The chemical attacks used in the early stages of the war, including those by Germany, France, and Great Britain, employed gas cylinders and relied upon wind to move clouds of poisonous vapor toward enemy lines. This tactic required a fair amount of luck to succeed. Later, both sides introduced delivery systems, including artillery shells and the Livens projector, that increased the probability that gas would actually reach its intended target.

Table W-1: Major Chemical Warfare (CW) Agents Developed and Produced during World War I

Chemical Agent	*First Use*
Chlorine	April 1915
Phosgene	1915–1916
Hydrogen cyanide	1916
Diphosgene	1916
Chloropicrin	1916
Mustard	July 1917
Lewisite	(Not used)

For chemical defenses, militaries frantically sought makeshift protective gear such as improvised masks. Chemical gas filters and protective eyepieces were invented, reducing the effectiveness of the potent CW agents. According to German army records, through the end of 1916, the mortality rate from CW agents was 50–60 percent, but then it dropped to 10–20 percent by the end of the war. As protective masks were being produced to outfit every soldier deployed in battle (as well as their horses, in some cases), Germany developed chemical compounds that could defeat Allied protective measures. One of these CW agents, diphenylcyanoarsine (DC), was an arsenical compound that was meant to be delivered in fine particles. The intent in this was to break through the masks, but such *Buntkreuz* or *Buntschiessen* techniques (both named for the color pattern painted on the shells) were ultimately unsuccessful.

Supported by Germany's advanced dye industry, which supplied the necessary chemical precursors, and with Haber's technical acumen, Germany developed processes for mass production of mustard agent. This highly effective casualty agent was also introduced on the Ypres battlefield in 1917. The most important feature of mustard is that it can penetrate clothing (including rubber), making life miserable for the Allied soldiers. But France and Britain were soon able to respond with sulfur mustard ("yperite"), and Corporal Adolf Hitler would himself be injured by this blister agent in 1918. Although its mortality was low in comparison to gases such as phosgene, mustard was responsible for the most injuries caused by CW agents throughout the entire war. For example, one month after Germany first began using mustard on the battlefield, British casualties from mustard approached the number of all those that had been caused by chemical weapons during the previous 2 years. Until the advent of highly toxic agents such as VX nerve agent in the 1950s, mustard was known as the king of CW agents.

The United States engaged its chemical manufacturing capacity to prepare for CW in World War I, although its late entry in the war (1917) meant that few of its chemical weapons would be used in battle. Lewisite, for example, was developed as a weapon, and large quantities were manufactured in 1917. By the time lewisite reached Europe, however, the war was already over.

Table W-2: World War I Casualties from Chemical Weapons

Country	*Wounded*	*Fatalities*
Austro-Hungary	97,000	3,000
Britain	180,597	8,109
France	182,000	8,000
Germany	191,000	9,000
Italy	55,373	4,627
Russia	419,340	56,000
United States	71,345	1,426
Others	9,000	1,000

Approximately 125,000 tons of chemical munitions were expended in World War I, delivered primarily by 65 million artillery shells. Perhaps as many as 13 million rounds were unexploded and today still litter the landscape of former European battlefields.

The belligerents of World War I later took pains to justify their use of chemical weapons, noting the right to retaliate against Germany's precedent at Ypres in 1915. Germany used a similar justification for what it claimed was French use of chemical weapons the year before. Other politicians and scholars of that era also noted that, when compared to the horrors of conventional warfare—bullets, shrapnel, and the like—in the end, CW was not that much worse. In 1920, the surgeon general of the United States summarized this feeling in the following way: "Gas is twelve times as humane as bullets and high explosives. That is to say, if a man gets gassed on the battlefield he has twelve times as many chances to get well as if he is struck by bullets or high explosives" (Ewing, p. 59). Still, there was enough visceral and vocal reaction among the general public in the United States and Europe to chemical warfare to set the stage for the Geneva Gas Protocol of 1925.

Biological Warfare (BW) during World War I

By 1914, the microbiological sciences had reached a level of development at which they were able to produce pathogens as a means of warfare. Reportedly, some German scientists considered the use of biological agents against the Allies, but their government would not allow it. One account is that of a German military doctor, who suggested to his superiors that plague bacteria (*Yersinia pestis*) could be dropped upon England from zeppelins. In reply, he was told, "My dear *Stabsarzt* (medical officer), all respects to your courage and patriotism, but if we undertake this step we will no longer be worthy to exist as a nation" (Wheelis, p. 38).

Nonetheless, a German-American physician by the name of Dr. Anton Dilger did conduct covert BW against American pack animals, culturing causative agents of anthrax and glanders at his home in Washington, D.C. He and other German agents paid Baltimore stevedores to assist them by inoculating some 3,000 mules, horses, and cattle bound for the Allies in Europe. (It is still unknown how these operatives managed to use highly infectious bacteria such as *Burkholderia mallei,* the causative agent of glanders, without becoming infected themselves. It is possible that they were also infected.) In World War II, a German expert in biological weapons recorded that these "agents took the cultures with them . . . cultivated the glanders bacilli with Ragitagar-gylcerine, which they had brought along, suspended the cultures and painted the nostrils of horses with the material" (Wheelis, p. 42). In a retrospective lecture delivered at Fort Detrick in 1944, it was posited that foot-and-mouth disease might also have been used against Allied horses and cattle that were being sent to the front in World War I. There is as of yet no conclusive evidence, however, that large numbers of animals or military personnel were affected by these acts of biological sabotage.

—Eric A. Croddy

THE BATTLE OF MESSINES, 1917

Under the leadership of British General Herbert Plumer, twenty-one underground explosive charges (these were referred to as mines, but this understates their actual mass) were placed by sappers beneath German lines. General Plumer made the now-famous remark to his staff before the mines were to be exploded: "Gentlemen, we may not make history tomorrow, but we shall certainly change the geography." Each of these charges had an estimated 40,000 pounds of explosives, and of these, nineteen detonated at almost exactly the same time on June 7, 1917. It is impossible to prove, but it is said that Prime Minister Lloyd George heard the blast in Downing Street, London.

Nor are there reliable records available as to how many Germans died. Most say, however, that Germany lost 10,000 men in the blast.

See also: Biological Warfare; Chemical Warfare; Choking Agents (Asphyxiants); Mustard (Sulphur and Nitrogen); Vesicants

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WORLD WAR II: BIOLOGICAL WEAPONS

During World War II, most major combatants conducted research on biological weapons. The Japanese undoubtedly used BW against the Chinese, but Japanese preparations for a BW attack against U.S. forces miscarried. The Russian front probably saw improvised biological attacks against German troops by Soviet and Polish partisans. Allegations that the Soviet national BW program mounted a BW attack are controversial. Other than these incidents, national military BW programs were limited to defensive actions and to offensive research programs of varying extent.

After World War I, popular outrage at the horrors of gas warfare led to several arms limitation treaties. The 1925 Geneva Protocol outlawed use of bacteriological agents in war, though it did not address the development of such weapons or the possession of biological weapons held for possible retaliation in kind.

There was a scientific consensus, however, that technical barriers made effective, reliable biological weapons impractical, if not impossible, to develop. Because military budgets were small, most countries did not investigate the development of biological weapons until the late 1930s when another war seemed likely.

The U.S.S.R. and Japan were exceptions to this general disinterest in biological warfare. Information on the Soviet biological weapons program is scant, but the program appears to have begun as early as the 1920s and remained active through the 1930s and 1940s, although it was disrupted by the Stalinist purges of the late 1930s. The Japanese biological weapons program began in 1932, spawned by a suspicion that the 1925 Geneva Protocol ban and the U.S. refusal to ratify it indicated that BW agents might be a valuable weapon.

The Canadian, French, British, and, possibly, the Polish governments began biological weapons programs in the 1930s as the rise of Fascism threatened another European war and as erroneous reports indicated German interest in BW. The French and Polish programs ended with the German occupation in 1939–1940. Italy briefly investigated BW in the 1930s but determined that the technical difficulties were too substantial to warrant further research. Germany showed little interest in BW until the fall of France revealed the French BW program. The Germans then belatedly began a small, ineffectual biological weapons program. The U.S. government began a biological weapons program in 1942 in response to threats perceived from Germany and Japan.

European Theater

As mentioned above, Great Britain and Canada started biological weapons programs in the late 1930s in response to reports of biological weapons development in Germany. Their efforts were limited in scale, and they concentrated on developing improvised offensive weapons, such as contaminated baits to infect enemy livestock and crude anthrax antipersonnel bombs. These were to be used for retaliation in kind should Germany use biological weapons.

Intelligence reports that both Germany and Japan were developing biological weapons resulted in the creation of the U.S. BW program. The U.S., British, and Canadian programs were coordinated and expanded to develop defensive measures as well as alternate, more sophisticated offensive systems.

The most important defensive program in the European theater was the development of an immunization against botulism toxin. Intelligence reports (which later proved to be inaccurate) indicated that Germany was preparing to use botulism toxin as a weapon to repel the Allied invasion of Europe. A crash program therefore developed a vaccine that protected humans against the botulism toxin. Sufficient material was manufactured to immunize the entire Allied force invading France on D-Day, but the immunization program was cancelled because more reliable intelligence became available that discounted the risk of such a German BW attack and because of the mistrust of new immunizations after a contaminated yellow fever vaccine had caused thousands of cases of hepatitis in 1942. At the end of the war, the German BW threat was found to have been inconsequential.

Little definitive information is available regarding BW in the Russian theater during the war. The Germans reported several instances of improvised biological sabotage of food by Russian and Polish partisans and resistance fighters. An allegation that the Russian military BW program may have deliberately caused an outbreak of tularemia is unproven. Many alleged incidents of biological warfare are probably due to naturally occurring disease outbreaks induced by the dislocation and disruption of sanitary and health services, caused by the war itself.

World War II storage of mustard agent shells, United States. (Bettmann/Corbis).

Pacific Theater

The earliest indications that the United States might face a biological attack from an opponent were the multiple attempts, beginning in 1939, by Japanese agents to obtain virulent and vaccine strains of the yellow fever virus. Japan had no legitimate use for yellow fever virus because yellow fever does not occur naturally in Asia or the Pacific region. Moreover, transport of even laboratory samples of the virus to Asia was forbidden by international agreement. Strategic U.S. bases in the Hawaiian Islands and Panama were highly vulnerable to introduction of yellow fever, as were wide areas of the mainland United States. This threat resulted in the decision immediately after Pearl Harbor to immunize all U.S. military personnel against yellow fever. Unfortunately, some lots of the vaccine had been contaminated with hepatitis

B virus, resulting in 350,000 cases of hepatitis requiring 50,000 hospitalizations.

In late 1941, reports reached Allied intelligence services that epidemics of plague in Chinese cities had been caused by the deliberate dropping of plague-infected fleas from Japanese aircraft. These reports were found to be persuasive by the leading U.S. expert in plague, and a crash program was instituted to produce plague vaccine. Because of the concern that plague would be used against U.S. forces, many U.S. military personnel were immunized against plague even though plague had never occurred in the areas of the Pacific where fighting occurred. When DDT became available near the end of World War II, it was used liberally to kill fleas, a traditional plague vector.

Concern that Japanese agents or sympathizers might use bacteria to contaminate food or drug supplies resulted in an extensive monitoring program in the Hawaiian Islands. All pharmacists, bacteriologists, and food handlers with a Japanese heritage were investigated for loyalty. A Caucasian soldier was stationed, full-time, in every food preparation facility in the Hawaiian Islands where a person of Japanese decent worked, in order to monitor the activity for possible tampering. Later in the war, similar monitoring was established in the Panama Canal zone.

In 1944, Japan began to release special high-altitude balloons carrying warheads that could reach the jet stream and cross the Pacific Ocean to fall on North America. Nearly 10,000 such balloons were released, and more than 250 reached the United States or Canada. They carried explosive and incendiary warheads intended to cause forest fires, but the small payload and the random nature of the targeting immediately gave rise to fears that they might carry biological agents. An intensive program of surveillance for balloons, analysis of the balloons' payloads, and monitoring of both human and livestock health throughout the United States and Canada was undertaken, all under intense secrecy. Although no evidence was found that biological agents were part of the payloads, a joint U.S.-Canadian program to produce veterinary vaccines against maliciously introduced exotic livestock diseases was reactivated. Postwar investigations revealed that a biological weapon warhead had been in development for balloon delivery, but it reportedly was not used.

In 1944, the United States was poised to invade the Mariana Islands, the proximity of which would allow U.S. planes to bomb the home islands of Japan. To strengthen the Pacific island defenses against the expected U.S. invasion, Japan sent a special contingent of biological warfare troops from China, but a U.S. submarine torpedoed the ship they were traveling on, and all of their equipment and biological agents were lost.

In late 1945, the Japanese devised a plan to close the Panama Canal by delivering a BW attack from submarine-launched aircraft. Although Japan possessed the necessary submarines, planes, and BW material, the war ended before the mission could depart.

The United States was near production of anticrop biological agents and antiplant chemical growth regulators (defoliants) in late 1945. These agents were developed as part of the U.S. BW program. Plans to starve the Japanese by attacking their crops were discarded, however, as the U.S. military had to consider its responsibilities for postwar reconstruction and feeding the Japanese population.

—Martin Furmanski

See also: Herbicides; Japan and WMD; Sino-Japanese War; Unit 731; United Kingdom: Chemical and Biological Weapons Programs; United States: Chemical and Biological Weapons Programs

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WORLD WAR II: CHEMICAL WEAPONS

Despite the widespread use of chemical weapons in World War I and the fact that all major belligerents possessed substantial chemical arsenals, combat use of toxic weapons in World War II was limited to the Sino-Japanese War. World War II saw the use of incendiary weapons on a scale that produced several urban firestorms, qualifying them as a weapon of mass destruction. Toxic gases were also used by the German military to murder millions of civilians in the death camps of the Holocaust.

Despite the fact that the 1925 Geneva Protocol banned the first use of chemical weapons, there was popular suspicion in the late 1930s that chemical weapons would be used in the event of war, against both military and urban targets. All major armies continued to supply antigas equipment and training to their troops during World War II. Officials were also concerned about the use of chemical weapons in terror bombing campaigns against cities.

European Theater

All European belligerents had ratified the 1925 Geneva Protocol banning first use of chemical weapons. Both the Allies and the Axis issued repeated pledges to refrain from first use of chemical weapons, and none were used in combat. Although Great Britain considered the option of first use of chemical weapons on British beaches to repel a German invasion, and although Great Britain evaluated the desirability of first use of CW to shorten the war, the decision was never made to employ chemical warfare against the Nazis. Throughout the war, however, both the Allies and the Axis did maintain large stockpiles of chemical munitions to allow retaliation in kind. A tragic accident in late 1943 in Bari, Italy, turned out to be the largest CW use of the war: When a U.S. merchant ship carrying mustard bombs was hit in a German air raid, it filled the harbor and adjacent city with mustard fumes, causing hundreds of chemical casualties.

Great Britain took the threat of CW against urban areas seriously, and it supplied its urban civilians with gas masks. The British also attempted to create a national CW detection system by painting postal deposit boxes with a paint that changed color if exposed to CW agents. Within a few days of the onset of the war, most children in the cities were evacuated to the countryside, which protected them against air bombardment and the possibility of chemical attacks against cities. Germany did not mount a comparable effort to protect its civilian population, and this may have contributed (along with Hitler's personal experience of being gassed in WWI) to the Nazis' reluctance to initiate chemical warfare and thereby risk retaliation in kind.

Nazi reluctance to engage in chemical warfare was not a forgone conclusion, however, because German development of nerve agents during the war gave the Nazis an edge in chemical warfare. Not only were these agents' orders of magnitude more deadly than the stockpiles of chemical agents maintained by the Allies, but the existing antigas equipment the Allies possessed would have been ineffective against them. Use of these nerve agents might have had profound military and political consequences. Although the Allies had air superiority, the Germans' V-1 and V-2 rockets would have been ideal nerve agent delivery systems. Indeed, despite the devastation they caused, Allied intelligence officials breathed a sigh of relief when the first V-1s and V-2s released by the Germans exploded conventionally on impact, giving conclusive proof that the Nazis had decided not to maximize their limited payloads by using them to deliver chemical weapons against urban targets.

Although primitive incendiary weapons had been developed in World War I, some believed that the large-scale incendiary bombardment of urban areas during World War II was the first modern example of a weapon of mass destruction. Incendiary attacks could result in "firestorms" destroying large urban areas in a single night. In three attacks in July–August 1943, 55 to 60 percent of Hamburg was destroyed, producing 60,000 to 100,000 fatalities. Between February 13 and 14, 1945, Dresden experienced a firestorm that killed more than 100,000 people.

Pacific Theater

Although Japan chose to use chemical weapons against Chinese troops and civilians in the Sino-Japanese War, it was careful to avoid such use against U.S. or British troops. The Japanese realized that the U.S. chemical arsenal was vastly superior to its own, and neither the United States nor Japan had ratified the 1925 Geneva Protocol. In other words, neither side was legally constrained against using chemical weapons first in combat.

Nevertheless, in 1942 and 1943, President Franklin Roosevelt stated a policy of no first use, but warned Japan that continued use of chemical weapons against China (now a member of the Allies) would be met with retaliation in kind by the United States. After these warnings, Japanese use of chemical weapons was greatly curtailed in China.

Japan became so concerned that an accident or an unauthorized chemical attack might provoke U.S. retaliation in kind, that all Japanese chemical munitions were withdrawn from forward areas in the Pacific theater in mid-1944.

Considerable planning by the United States for possible first use of chemical weapons occurred late in the war. Tests determined that CW would be effective against Japanese cave fortifications. Plans for a full-scale saturation of Iwo Jima with mustard gas prior to an invasion were prepared, but these plans were cancelled by President Roosevelt. The use of CW during the invasion of the Japanese home islands was considered, but it was made moot by the Japanese surrender.

The U.S. Army Air Corps employed incendiary weapons widely against highly flammable Japanese cities. On several occasions, these attacks produced firestorms or conflagrations that devastated entire cities. The most deadly incendiary attack occurred between March 9 and 10, 1945, when 25 percent of Tokyo was destroyed by fire, leaving more than 1,000,000 people homeless and killing nearly 84,000 Tokyo residents.

—Martin Furmanski

See also: Bari Incident; Sino-Japanese War; Wushe Incident

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WUSHE INCIDENT

The Wushe Incident was probably the first time that chemical weapons were used in Asia. In 1930, Japanese forces occupying the island of Taiwan (then called Formosa) used poison gas against a rebellious group of Taiwanese citizens. This rebellion had begun with a local misunderstanding—exacerbated by years of harsh Japanese rule—between a Japanese policeman and the leader of an indigenous tribe. This led to the massacre of about 134 Japanese people at a sports event in the Wushe region. In order to punish the rebels and restore imperial rule, Japanese military units, including aircraft, were deployed to the area. What happened next is under some dispute. According to one report, the local Taiwanese, with only ancient firearms and bows and arrows to protect themselves, retreated to a large cave where they held out against attack. The Japanese resorted to the use of poison gas to flush them out. The gas was air-delivered in canisters, which broke on impact to release a "white smoke." As one local poet (who was not present during the event) described it years later:

> *We couldn't breathe, choking smoke filled the air*
> *Tearfully, some fell; others were killed in the forest; still others jumped to their*
> *Deaths from the cliff; no way to breathe in the white smoke.* (Quoted in Balcom, p. 65)

This description backs up the assertion that the weapon used was most probably a form of tear gas known as chloracetophenon (CN). Other accounts, however, tell of villagers being found dead in their huts, leading to the conclusion that a more deadly form of gas was employed. Overall, Japanese reprisals for the insurrection resulted in the deaths of 644 Taiwanese people—more than half of the local population of Wushe.

In 1930, the use of chemical agents was proscribed under international law by the Geneva Protocol of 1925. Japan, although a signatory of the treaty, never ratified it. In light of the World War I experience when they were used to good effect, chemical weapons were perceived by the Japanese military as useful, especially against poorly armed opponents. The Japanese had begun experimental production of mustard gas in 1928, and they expanded both production and training for the use of chemical weapons throughout the 1930s. Indeed, a large chemical weapons facility was established in northern Taiwan. Chemical weapons, including tear gas, mustard gas, and hydrogen cyanide, were used widely, although with limited success, in Japan's war with China in the late 1930s and early 1940s. The use of chemical agents in that war led U.S. officials to fear that Japanese forces would employ them against American troops. Japan never employed chemical weapons against U.S. forces, however, and it apparently never again employed them after 1942.

—Rod Thornton

See also: Riot Control Agents; Sino-Japanese War

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X

XYLYL BROMIDE

Xylyl bromide falls into the general category of the so-called halogenated compounds. These chemicals contain a halogen, that is, chlorine, bromine, iodine, or fluorine, in their chemical structures. During World War I, Germany investigated a number of different chemical structures for development of irritating CW agents, but mostly owing to cost and availability, they settled upon bromine. Xylyl bromide was originally chosen for use, but due to xylyl bromide's low volatility, it was replaced by a closely related candidate, benzyl bromide, which was first used at Verdun by the German army in March 1915.

The use of chlorine (Cl_2) by Germany in April 1915 (at Ypres, Belgium) ushered in modern chemical warfare. Months earlier, however, the German military had tried to use xylyl bromide on the battlefield. This chemical attack took place on January 31, 1915 at Bolimow, Poland. Although a dianisidine chemical munition had been tried on October 27, 1914 by the German military, this use of xylyl bromide was probably the first recorded use of a chemical artillery shell in modern history. Xylyl bromide is an extremely irritating compound, but it had little demonstrable effect upon the Russian and British troops at Bolimow—despite Germany's having fired some 500 tons of this "T-Stoff."

Germany discovered that xylyl bromide corroded most metals and required lead canisters to hold the liquid for artillery shells. Xylyl bromide is a potent lacrimator (tear gas), detectable in concentrations as low as 0.0018 milligrams (about 2 micrograms) per liter. Though the effectiveness of xylyl bromide was questionable, especially during the winter when the cold lowered its volatility, its use in artillery shells opened the door for more advanced chemical weaponry to follow.

—*Eric A. Croddy*

See also: World War I

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Y

YELLOW RAIN

Yellow rain refers to a family of chemically related toxins produced by fungi, purportedly making up the active ingredient in a toxic weapon. These fungal toxins (mycotoxins) were allegedly weaponized by the Soviet Union and used in Cold War conflicts such as those in Afghanistan, Laos, Kampuchea (Cambodia), and possibly Vietnam. The material was likely dispersed in droplet or aerosol form from aircraft, hence the term *yellow rain.* Rumors of the use of mycotoxins by the Soviets had circulated in the international community since the early 1970s, and Alexander Haig, the U.S. Secretary of State, made an emphatic allegation of the Soviets' use of yellow rain at a press conference in Berlin in September 1981. In March of the following year, Secretary Haig issued a written report formally accusing the Soviet Union and its client states of using mycotoxins against human targets in southeast Asia and in Afghanistan.

A large number of fungal metabolites (by-products of metabolism) have been implicated in adverse health effects in humans and domestic animals. Fungal growth on hay, rice, wheat and other cereal grains, cotton, and other agricultural products has been demonstrated to produce significant concentrations of mycotoxins. Of the many mycotoxins known to cause tissue damage in animals, the trichothecene family contains several toxic compounds, among which the T-2 mycotoxin is particularly harmful to humans and domestic livestock.

Controversial claims that the Soviets or Soviet clients used yellow rain have been based on the probable, but never proven, use of trichothecenes in southeast Asia and Afghanistan during the period from 1974 to 1981. Evidence compiled by U.S. intelligence analysts under the direction of the Working Group on Chemical/Biological Warfare Use, summarized in the State Department's 1982 monograph, cited epidemiological support for intelligence estimates of the biological warfare use of trichothecenes. Specific among these allegations were a series of attacks against Hmong villagers in the Laotian highlands in 1975–1981 and against Khmer Rouge troops in North Vietnam and Laos in 1979–1981. Scientific investigations, however, failed to provide unequivocal proof that trichothecenes were employed as biological warfare agents by the Soviets or the Laotian military.

Despite the apparent lack of a "smoking gun," considerable circumstantial and empirical findings strongly supported the allegations of use. The United States and its allies, for example, recovered and identified trichothecenes from both human and environmental specimens. Interviews with Hmong villagers who had survived or witnessed the aerial dispersion of yellow rain in Laos offered consistent and relevant testimony that supported the use of yellow rain. Defectors, including Laotian and North Vietnamese military personnel, also recounted in separate interviews the use of yellow rain, giving detailed information consistent with the testimony of local villagers. Repeated admissions of unconventional weapons use in southeast Asia and Afghanistan were recorded by intelligence officers from interrogated prisoners of war, with specific mention of yellow rain. Chemical warfare agents and Soviet technicians were also discovered in Laos.

Although the U.S. government's investigation provided considerable circumstantial evidence of Soviet-sponsored trichothecene use against human targets, the controversy was fueled by a lack of convincing scientific proof. Attempts by the United Nations to investigate the yellow rain allegations were derailed by the refusal of the Laotian and Vietnamese governments to cooperate with investigators and by their adamant denial of requests for access to alleged yellow rain sites. The Soviet and Russian governments have never admitted to the use of biological agents, and they have categorically refuted all such allegations.

Since the allegations were made, the passage of time, questionable investigation practices, disingenuous political influence, and a general disintegration of public concern over the military threat once posed by the Soviet Union have largely deflated the yellow rain controversy. Russian government officials have thus far declined to discuss related issues in recent years. Finally, the preponderance of evidence cited in Haig's 1982 report is constrained by security classifications that render it immune to public retrieval under the Freedom of Information Act. Thus, the putative use of yellow rain as a biological warfare agent remains a mystery and is likely to remain so for the foreseeable future.

Technical Details

Trichothecene mycotoxins are low molecular weight compounds that exhibit remarkable stability in the environment. The trichothecene family of toxins is characterized by a common tetracyclic (four carbon ring) trichothecene molecular structure with various side chain groups (molecular attachments) conferring specific chemical and toxic properties. Trichothecenes are nonvolatile (do not evaporate under normal conditions) and do not readily dissolve in water; large-scale production typically requires extraction from organic solvents. The toxins are not degraded by exposure to air, sunlight, or autoclaving; the compounds require high temperatures for extended time periods to be inactivated.

Filamentous fungi ("molds") are ubiquitous in nature, and dangerous levels of mycotoxins have been reported in grains, hay, and livestock feeds where these molds grow. Domestic animals are the most frequent victims of naturally occurring mycotoxicoses (poisoning events caused by mold), usually following ingestion of moldy feed or hay. Human intoxication is most often associated with fungal contaminants of rice, corn, barley, wheat, and other cereal grains that are unknowingly consumed in sufficient quantities for the victim to manifest symptoms. Natural production of the toxins often exhibits a distinct seasonality, generally coinciding with climatic conditions conducive to sustained fungal growth.

Trichothecenes effectively inhibit protein synthesis in a large number of cell types and are particularly toxogenic (poisonous) in rapidly proliferating host tissues. Some evidence suggests that the T-2 mycotoxin also causes damage to RNA and inhibits DNA synthesis, although these specific toxic effects are probably indirect effects of the inhibition of protein synthesis.

Trichothecenes, in particular T-2, are biologically active following skin absorption, oral ingestion, or inhalation. This is unique among known biological agents. Following absorption, systemic toxicity (poisoning throughout the body) occurs rapidly, then T-2 passes across the intestinal or pulmonary mucosa (layer of tissue in lung), with lethal effects recorded within 1 hour after experimental infection in laboratory animals. Transdermal uptake is considerably slower, although the use of a dermal penetrant increases the movement of T-2 through the skin. In fact, the presence of a dermal penetrant helps distinguish manufactured and purified trichothecenes from naturally occurring mycotoxins, which lack these chemical additives. Regardless of how they may be weaponized, the effective movement of the trichothecenes into systemic circulation, and their ability to achieve biologically effective concentrations after relatively short exposure periods, makes this class of compounds effective when formulated as powders, aerosols, or droplet sprays.

Considering their resistance to environmental degradation, their rapid uptake across biological membranes, the ability to achieve toxic levels within a short exposure interval, and the absence of sophisticated protocols for production, T-2 and related trichothecenes are serious candidates for weaponization and employment in an unconventional setting. The ability to harvest selected trichothecenes from liquid culture in substantive quantities and the ready availability of fermentation equipment make mycotoxins attractive biological agents for small- to medium-scale production with a minimal investment in technology or scientific prowess.

—*J. Russ Forney*

See also: Mycotoxins

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YEMEN

Concerns exist about contacts the Republic of Yemen has had with "rogue states," such as North Korea (Democratic People's Republic of Korea, or DPRK), and about Yemen as a possible training ground for international terrorists. Yemen's role as a possible base for international terrorists was highlighted by the attack on the USS *Cole* by a small boat loaded with high explosives on October 12, 2000, killing 17 U.S. Navy personnel, and the October 6, 2002, attack on the French supertanker *Limburg.* The French oil tanker was also hit off the coast of Yemen. During counterterrorist operations and in cooperation with Yemen, this latest attack was followed by a U.S. Hellfire rocket strike launched by a Predator aircraft (UAV) against suspected al-Qaeda operatives in November 2002.

Yemen, situated on the southeastern coast of the Arabian peninsula, was the site of a chemical weapons attack in the 1960s when Egyptian forces used mustard in attacks on Saudi Arabian-backed Royalist Yemeni forces. The civil war began with two competing entities, each hoping to rule Yemen after the death of the Imam (leader) in 1962. Egypt and the Soviet Union supported the military officers who formed the republican opposition, while the Imam royalists were supported by Saudi, Jordan, and Iran. At least by 1967, Egypt was using chemical warfare agents, including mustard, in the Yemeni conflict. Some reports claim that Egypt also used an organophosphate nerve agent against Royalist Yemeni forces. This was the first use of chemical weapons in the Middle East, and was of great concern to Israel as Egypt and other Arab countries prepared to invade in what would later be called the Six Day War (June 1967).

Today, Yemen has several aircraft capable of carrying weapons of mass destruction, including MiG-29s purchased from Russia. Yemen has no nuclear capability, however, and there is no evidence that it has undertaken any research in this field for either energy or weaponry purposes. It acceded to the Nuclear Nonproliferation Treaty on October 31, 1973, and signed the Comprehensive Test Ban Treaty on September 30, 1996.

Yemen has a number of Scud B ballistic missiles that have a range of 300 kilometers when carrying a 985-kilogram payload. A number of shorter-range Scuds were used during the 1994 civil war. It has purchased No Dong missiles from North Korea. A shipment of fifteen missiles was delivered in December 2002 after having been intercepted at sea (and subsequently released) by U.S. and Spanish maritime forces. Yemeni officials have pledged to purchase no additional missiles from North Korea and have stated that the missiles delivered at the end of 2002 were for only defensive purposes and would not be sold or transferred to third parties. Yemen does not, however, subscribe to the main international missile nonproliferation agreement, the Missile Technology Control Regime.

There is no evidence that Yemen has a chemical or biological weapons program. It signed the Chemical Weapons Convention (CWC) on February 8, 1993. The CWC entered into force for Yemen on November 1, 2000.

—J. Simon Rofe

See also: Mustard (Sulfur and Nitrogen); Organophosphates; Vesicants

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YPRES

Ypres, a small Flemish market town near the border of France, was the scene of some of the worst fighting in the First World War. Even more infamously, it is where poison gas was first used effectively in combat.

In the spring of 1915, British, Canadian, and French forces maintained a 10-mile military salient near Ypres that bulged into German occupied territory for 5 miles. During the morning of April 22, German troops mounted a heavy bombardment on the enemy line. When shelling resumed in the evening, French sentries noticed a curious yellow-green cloud drifting slowly toward their positions. They suspected that the cloud masked a German infantry attack, but no enemy troops advanced. What the Germans had done was open the valves of several thousand cylinders of chlorine gas, using a favorable wind to carry more than 160 tons of the deadly agent across the mostly French and Algerian lines. Those least affected experienced intense irritation of the eyes and difficulty breathing, causing damage to the tissue of the lungs. The lungs of those who were more exposed became flooded with fluid, resulting in slow and painful drowning. In this attack alone, it was reported that 5,000 Allied soldiers were killed, and another 10,000 were seriously injured. However, subsequent historians note that this was likely an exaggeration on the part of Allied propaganda. To be certain, at least 800 soldiers were killed in this gas attack.

Ironically, the Germans failed to fully exploit this attack. Panic-stricken French troops fled in disorder, creating a 4-mile gap in the Allied line. Had the Germans anticipated this outcome, they could have mounted a decisive breakthrough. The results of their experiment, however, caused as much surprise to the German high command as confusion within the opposing ranks.

Although the German infantry did seize control of a significant portion of the salient, the Allies nevertheless managed to re-form a continuous line, though in areas it remained dangerously weak. Germany used chlorine gas several more times on the Ypres salient during the spring of 1915. In their last chemical attack on May 24, they released chlorine gas over a front of 4.5 miles and took the Bellewaarde Ridge, thus gaining almost all the high ground around Ypres. This was to shape the salient over the next two "Quiet Years."

Germany's introduction of chemical warfare at Ypres provoked widespread international condemnation and certainly damaged German relations with the neutral powers, including the United States. The Ypres attack, however, brought an end to Germany's internal debate and hesitancy over the use of chemical weapons on the battlefield.

Once the Allies had recovered from the initial shock of the Germans' practical application of poison gas warfare, a determination existed to exact retaliation at the earliest opportunity. The British were the first to respond, using chlorine gas at the Battle of Loos in September 1915. After this incident, chemical warfare escalated both quantitatively and qualitatively for the remainder of the war.

—Peter Lavoy

See also Chlorine Gas; Choking Agents (Asphyxiants); World War I

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DECLARATION PROHIBITING THE USE OF ASPHYXIATING GASES

The undersigned, Plenipotentiaries of the Powers represented at the International Peace Conference at The Hague, duly authorized to that effect by their Governments, inspired by the sentiments which found expression in the Declaration of St Petersburg of 29 November (11 December) 1868.

DECLARE as follows:

The Contracting Powers agree to abstain from the use of projectiles the object of which is the diffusion of asphyxiating or deleterious gases.

The present Declaration is only binding on the Contracting Powers in the case of a war between two or more of them.

It shall cease to be binding from the time when, in a war between the Contracting Powers, one of the belligerents shall be joined by a non-Contracting Power.

The present Declaration shall be ratified as soon as possible.

The ratifications shall be deposited at The Hague.

A *procès-verbal* shall be drawn up on the receipt of each ratification, a copy of which, duly certified, shall be sent through the diplomatic channel to the Contracting Powers.

The non-Signatory Powers can adhere to the present Declaration. For this purpose they must make their adhesion known to the Contracting Powers by means of a written notification addressed to the Netherland Government, and by it communicated to all the other Contracting Powers.

In the event of one of the High Contracting Parties denouncing the present Declaration, such denunciation shall not take effect until a year after the notification made in writing to the Government of the Netherland, and forthwith communicated by it to all the other Contracting Powers.

This denunciation shall only affect the notifying Power.

IN FAITH OF WHICH the Plenipotentiaries have signed the present Declaration, and affixed their seals thereto.

DONE at The Hague the 29th July, 1899, in a single copy, which shall be kept in the archives of the Netherland Government, and copies of which, duly certified, shall be sent by the diplomatic channel to the Contracting Powers.

HAGUE DECLARATIONS:

Peace Conference at the Hague 1899:

General Report of the United States Commission
THE HAGUE, July 31, 1899.
THE HONORABLE JOHN HAY, Secretary of State,

Sir: On May 17, 1899, the American Commission to the Peace Conference of The Hague met for the first time at the house of the American Minister, The Honorable Stanford Newel, the members in the order named in the instructions from the State Department being Andrew D. White, Seth Low, Stanford Newel, Captain Alfred T. Mahan of the United States Navy, Captain William Crozier of the United States Army, and Frederick W. Holls, Secretary. Mr. White was elected President and the instructions from the Department of State were read.

On the following day the Conference was opened at the Palace known as "The House in the Wood," and delegates from the following countries, twenty-six in number, were found to be present: Germany, The United States of America, Austria-Hungary, Belgium, China, Denmark, Spain, France, Great Britain and Ireland, Greece, Italy, Japan, Luxemburg, Mexico, Montenegro, The Netherlands, Persia, Portugal, Roumania, Russia, Servia, Siam, Sweden and Norway, Switzerland, Turkey and Bulgaria.

The opening meeting was occupied mainly by proceedings of a ceremonial nature, including a telegram to the Emperor of Russia and a message of thanks to the Queen of the Netherlands, with speeches by M. de Beaufort, the Netherlands Minister of Foreign Affairs, and M. de Staal, representing Russia.

At the second meeting a permanent organization of the Conference was effected, M. de Staal being chosen President, M. de Beaufort honorary President, and M. van Karnebeek, a former Netherlands Minister of Foreign Affairs, Vice-President. A sufficient number of Secretaries was also named.

The work of the Conference was next laid out with reference to the points stated in the Mouravieff circular of December 30, 1898, and divided between three great committees as follows:

The first of these committees was upon the limitation of armaments and war budgets, the interdiction or discouragement of sundry arms and explosives which had been or might be hereafter invented, and the limitation of the use of sundry explosives, projectiles, and methods of destruction both on land and sea, as contained in Articles 1 to 4 of the Mouravieff circular.

The second great committee had reference to the extension of the Geneva Red Cross Rules of 1864 and 1868 to maritime warfare, and the revision of the Brussels Declaration of 1874 concerning the laws and customs of war and contained in Articles 5 to 7 of the same circular.

The third committee had as its subjects, mediation, arbitration, and other methods of preventing armed conflicts between nations, as referred to in Article 8 of the Mouravieff circular.

The American members of these three committees were as follows: of the first committee, Messrs. White, Mahan, Crozier; of the second committee, Messrs. White, Newel, Mahan, Crozier; of the third committee, Messrs. White, Low and Holls.

In aid of these three main committees sub-committees were appointed as follows:

The first committee referred questions of a military nature to the first sub-committee of which Captain Crozier was a member, and questions of a naval nature to the second sub-committee of which Captain Mahan was a member.

The second committee referred Articles 5 and 6, having reference to the extension of the Geneva Rules to maritime warfare to a sub-committee of which Captain Mahan was a member, and Article 7, concerning the revision of the laws and customs of war, to a sub-committee of which Captain Crozier was a member.

The third committee appointed a single sub-committee, of "examination," whose purpose was to scrutinize plans, projects, and suggestions of arbitration, and of this committee, Mr. Holls was a member.

The main steps in the progress of the work wrought by these agencies, and the part taken in it by our Commission are detailed in the accompanying reports made to the American Commission by the American members of the three committees of the Conference. It will be seen from these that some of the most important features finally adopted were the result of American proposals and suggestions.

As to that portion of the work of the First Committee of the Conference which concerned the non-augmentation of armies, navies, and war budgets for a fixed term and the study of the means for eventually diminishing armies and war budgets, namely Article 1, the circumstances of the United States being so different from those which obtain in other parts of the world and especially in Europe, we thought it best, under our instructions, to abstain from taking any active part. In this connection, the following declaration was made:

The Delegation of the United States of America has concurred in the conclusions upon the first clause of the Russian letter of December 30, 1898, presented to the Conference by the First Commission, namely: that the proposals of the Russian representatives, for fixing the amounts of effective forces and of budgets, military and naval, for periods of five and three years. cannot now be accepted, and that a more profound study upon the part of each State concerned is to be desired. But, while thus supporting what seemed to be the only practicable solution of a question submitted to the Conference by the Russian letter, the Delegation wishes to place upon the Record that the United States, in so doing, does not express any opinion as to the course to be taken by the States of Europe.

This declaration is not meant to indicate mere indifference to a difficult problem, because it does not affect the United States immediately, but expresses a determination to refrain from enunciating opinions upon matters into which, as concerning Europe alone, the United States has no claim to enter. The resolution offered by M. Bourgeois, and adopted by the First Commission, received also the hearty concurrence of this Delegation, because in so doing it expresses the cordial interest and sympathy with which the United States, while carefully abstaining from anything that might resemble interference, regards all movements that are thought to tend to the welfare of Europe. The military and naval armaments of the United States are at present so small, relatively, to the extent of territory and to the number of the population, as well as in comparison with those of other nations, that their size can entail no additional burden of expense upon the latter, nor can even form a subject for profitable mutual discussion.

As to that portion of the work of the first committee which concerned the limitations of invention and the interdiction of sundry arms, explosives, mechanical agencies, and methods heretofore in use or which might possibly be hereafter adopted both as regards warfare by land and sea, namely, Articles 2, 3, and 4, the whole matter having been divided between Captains Mahan and Crozier, so far as technical discussion was concerned, the reports made by them from time to time to the American Commission formed the basis of its final action on these subjects in the first committee and in the Conference at large.

The American Commission approached the subject of the limitation of invention with much doubt. They had been justly reminded in their instructions of the fact that by the progress of invention as applied to the agencies of war, the frequency, and indeed the exhausting character of war had been as a rule diminished rather than increased. As to details regarding missiles and methods, technical and other difficulties arose which obliged us eventually, as will be seen, to put ourselves on record in opposition to the large majority of our colleagues from other nations on sundry points. While agreeing with them most earnestly as to the end to be attained, the difference in regard to some details was irreconcilable. We feared falling into worse evils than those from which we sought to escape. The annexed Reports of Captains Mahan and Crozier will exhibit very fully these difficulties and the decisions thence arising.

As to the work of the Second great Committee of the Conference, the matters concerned in Articles 3 and 6 which related to the extension to maritime warfare of the Red Cross Rules regarding care for the wounded adopted in the Geneva Conventions of 1864 and 1868 were, as already stated, referred as regards the discussion of technical questions in the committee and sub-committee to Captain Mahan, and the matters concerned in Article 7, on the revision of the laws and customs of war were referred to Captain Crozier. On these technical questions Captains Mahan and Crozier reported from time to time to the American Commission, and these reports having been discussed both in regard to their general and special bearings, became the basis of the final action of the entire American Commission, both in the second committee and in the Conference at large.

As to the first of these subjects, the extension of the Geneva Red Cross Rules to maritime warfare, while the general purpose of the articles adopted elicited the especial sympathy of the American Commission, a neglect of what seemed to us a question of almost vital importance, namely: the determination of the status of men picked up by the hospital ships of neutral states or by other neutral vessels, has led us to refrain from signing the Convention prepared by the Conference touching this subject, and to submit the matter, with full explanation, to the Department of State for decision.

As to the second of these subjects, the revision of the laws and customs of war, though the code adopted and embodied in the third convention commends our approval, it is of such extent and importance as to appear to need detailed consideration in connection with similar laws and customs already in force in the army of the United States, and it was thought best, therefore, to withhold our signature from this Convention, also, and to refer it to the State Department with a recommendation that it be there submitted to the proper authorities for special examination and signed, unless such examination shall disclose imperfections not apparent to the Commission.

In the Third great Committee of the Conference, which had in charge the matters concerned in Article 3 of the Russian circular, with reference to good offices, mediation, and arbitration, the proceedings of the sub-committee above referred to became especially important.

While much interest was shown in the discussions of the first of the great Committees of the Conference, and still more in those of the second, the main interest of the whole body centered more and more in the third. It was felt that a thorough provision for arbitration and its cognate subjects is the logical precursor of the limitation of standing armies and budgets, and that the true logical order is, first, arbitration and then disarmament.

As to subsidiary agencies, while our Commission contributed much to the general work regarding good offices and mediation, it contributed entirely, through Mr. Holls, the plan for " Special Mediation," which was adopted unanimously, first by the committee and finally by the Conference.

As to the plan for "International Commissions of Inquiry" which emanated from the Russian Delegation, our Commission acknowledged its probable value, and aided in elaborating it; but added to the safeguards against any possible abuse of it, as concerns the United States, by our Declaration of July 25, to be mentioned hereafter.

The functions of such commissions is strictly limited to the ascertainment of facts, and it is hoped that, both by giving time for passions to subside and by substituting truth for rumor, they may prove useful at times in settling international disputes. The Commissions of Inquiry may also form a useful auxiliary both in the exercise of Good Offices and to Arbitration.

As to the next main subject, the most important of all under consideration by the third committee-the plan of a Permanent Court or Tribunal-we were able, in accordance with our instructions, to make contributions which we believe will aid in giving such a court dignity and efficiency.

On the assembling of the Conference, the feeling regarding the establishment of an actual, permanent tribunal was evidently chaotic, with little or no apparent tendency to crystallize into any satisfactory institution. The very elaborate and, in the main, excellent proposals relating to procedure before special and temporary tribunals, which were presented by the Russian Delegation, did not at first contemplate the establishment of any such permanent institution. The American plan contained a carefully devised project for such a tribunal, which differed from that adopted mainly in contemplating a tribunal capable of meeting in full bench and permanently in the exercise of its functions, like the Supreme Court of the United States, instead of a Court like the Supreme Court of the State of New York, which never sits as a whole, but whose members sit from time to time singly or in groups, as occasion may demand. The Court of Arbitration provided for, resembles in many features the Supreme Court of the State of New York, and courts of unlimited original jurisdiction in various other States. In order to make this system effective a Council was established, composed of the diplomatic representatives of the various Powers at The Hague, and presided over by the Netherlands Minister of Foreign Affairs, which should have charge of the central office of the proposed Court, of all administrative details, and of the means and machinery for speedily calling a proper bench of judges together, and for setting the Court in action. The reasons why we acquiesced in this plan will be found in the accompanying report This compromise involving the creation of a Council and the selection of judges, not to be in session save when actually required for international litigation, was proposed by Great Britain, and the feature of it, which provided for the admission of the Netherlands with its Minister of Foreign Affairs as President of the Council, was proposed by the American Commission. The nations generally joined in perfecting the details. It may truthfully be called, therefore, the plan of the Conference.

As to the revision of the decisions by the tribunal in case of the discovery of new facts, a subject on which our instructions were explicit, we were able, in the face of determined and prolonged opposition, to secure recognition in the Code of Procedure for the American view.

As regards the procedure to be adopted in the International Court thus provided, the main features having been proposed by the Russian Delegation, various modifications were made by other Delegations, including our own. Our Commission was careful to see that in this Code there should be nothing which could put those conversant more especially with British and American Common Law and Equity at a disadvantage. To sundry important features proposed by other Powers our own Commission gave hearty support. This was the case more especially with Article 27 proposed by France. It provides a means, through the agency of the Powers generally, for calling the attention of any nations apparently drifting into war, to the fact that the tribunal is ready to hear their contention. In this provision, broadly interpreted, we acquiesced, but endeavored to secure a clause limiting to suitable circumstances the "duty" imposed by the article. Great opposition being shown to such an amendment as unduly weakening the article, we decided to present a declaration that nothing contained in the convention should make it the duty of the United States to intrude in or become entangled with European political questions or matters of internal administration, or to relinquish the traditional attitude of our nation toward purely American questions. This declaration was received without objection by the Conference in full and open session.

As to the results thus obtained as a whole regarding arbitration, in view of all the circumstances and considerations revealed during the sessions of the Conference, it is our opinion that the " Plan for the Peaceful Adjustment of International Differences," which was adopted by the Conference, is better than that presented by any one nation. We believe that, though it will doubtless be found imperfect and will require modification as time goes on, it will form a thoroughly practical beginning, that it will produce valuable results from the outset, and that it will be the germ out of which a better and better system will be gradually evolved.

As to the question between compulsory and voluntary arbitration, it was clearly seen, before we had been long in session, that general compulsory arbitration of questions, really likely to produce war, could not be obtained; in fact, that not one of the nations represented at the Conference was willing to embark in it so far as the more serious questions were concerned. Even as to questions of less moment it was found to be impossible to secure agreement except upon a voluntary basis. We ourselves felt obliged to insist upon the omission from the Russian list of proposed subjects for compulsory arbitration, international conventions relating to rivers, to inter-oceanic canals, and to monetary matters. Even as so amended, the plan was not acceptable to all. As a consequence, the Convention prepared by the Conference provides for voluntary arbitration only. It remains for public opinion to make this system effective. As questions arise threatening resort to arms, it may well be hoped that public opinion in the nations concerned, seeing in this great international court a means of escape from the increasing horrors of war, will insist more and more that the questions at issue be referred to it. As time goes on such reference will probably more and more seem, to the world at large, natural and normal, and we may hope that recourse to the tribunal will finally, in the great majority of serious differences between nations, become a popular means of avoiding the resort to arms. There will also be another effect worthy of consideration. This is the building up of a body of international law growing out of the decisions handed down by the judges. The procedure of the tribunal requires that reasons for such decisions shall be given, and these decisions and reasons can hardly fail to form additions of especial value to international jurisprudence.

It now remains to report the proceedings of the Conference, as well as our own action, regarding the question of the immunity of private property not contraband, from seizure on the seas in time of war. From the very beginning of our sessions it was constantly insisted by leading representatives from nearly all the great Powers that the action of the Conference should be strictly limited to the matters specified in the Russian circular of December 30, 1898, and referred to in the invitation emanating from the Netherlands Ministry of Foreign Affairs.

Many reasons for such a limitation were obvious. The members of the Conference were, from the beginning, deluged with books, pamphlets, circulars, newspapers, broadsides, and private letters on a multitude of burning questions in various parts of the world. Considerable numbers of men and women devoted to urging these questions came to The Hague or gave notice of their coming. It was very generally believed in the Conference that the admission of any question not strictly within the limits proposed by the two circulars above mentioned would open the door to all those proposals above referred to and that this might lead to endless confusion, to heated debate, perhaps even to the wreck of the Conference and consequently to a long postponement of the objects which both those who summoned it and those who entered it had directly in view.

It was at first held by very many members of the Conference that under the proper application of the above rule, the proposal made by the American Commission could not be received. It required much and earnest argument on our part to change this view, but finally the Memorial from our Commission, which stated fully the historical and actual relation of the United States to the whole subject, was received, referred to the appropriate committee, and finally brought by it before the Conference.

In that body it was listened to with close attention and the speech of the Chairman of the Committee, who is the eminent President of the Venezuelan Arbitration Tribunal, nowin session at Paris, paid a hearty tribute to the historical adhesion of the United States to the great principle concerned. He then moved that the subject be referred to a future Conference. This motion we accepted and seconded, taking occasion in doing so to restate the American doctrine on the subject, with its claims on all the nations represented at the Conference.

The Commission was thus, as we believe, faithful to one of the oldest of American traditions, and was able at least to keep the subject before the world. The way is paved also for a future careful consideration of the subject in all its bearings and under more propitious circumstances.

The conclusions of the Peace Conference at The Hague took complete and definite shape in the final act laid before the Delegates on July 29th, for their signature. This Act embodied three Conventions, three Declarations, and seven Resolutions as follows:

First, a Convention for the peaceful adjustment of international differences. This was signed by sixteen Delegations, including that of the United States of America, there being adjoined to our signatures a reference to our declaration above referred to, made in open Conference on July 25, and recorded in the proceedings of that day.

Second, a Convention concerning the laws and customs of war on land. This was signed by fifteen Delegations. The United States Delegation refer the matter to the Government at Washington with the recommendation that it be there signed.

Third, a Convention for the adaptation to maritime warfare of the principles of the Geneva Conference of 1864. This was signed by fifteen Delegations. The United States representatives refer it, without recommendation, to the Government at Washington.

The three Declarations were as follows:

First: a Declaration prohibiting the throwing of projectiles and explosives from balloons or by other new analogous means, such prohibition to be effective during five years. This was signed by seventeen Delegations as follows: Belgium, Denmark, Spain, The United States of America, Mexico, France, Greece, Montenegro, The Netherlands, Persia, Portugal, Roumania, Russia, Siam, Sweden and Norway, Turkey and Bulgaria.

Second, a Declaration prohibiting the use of projectiles having as their sole object the diffusion of asphyxiating or deleterious gases. This, for reasons given in the accompanying documents, the American Delegation did not sign. It was signed by sixteen Delegations as follows: Belgium, Denmark, Spain, Mexico, France, Greece, Montenegro, The Netherlands, Persia, Portugal, Roumania, Russia, Siam, Sweden and Norway, Turkey and Bulgaria.

Third, a Declaration prohibiting the use of bullets which expand or flatten easily in the human body, as illustrated by certain given details of construction. This for technical reasons, also fully stated in the report, the American Delegation did not sign. It was signed by fifteen Delegations as follows: Belgium, Denmark, Spain, Mexico, France, Greece, Montenegro, The Netherlands, Persia, Roumania, Russia, Siam, Sweden and Norway, Turkey and Bulgaria.

The seven Resolutions were as follows:

First, a Resolution that the limitation of the military charges which at present so oppress the world is greatly to be desired, for the increase of the material and moral welfare of mankind.

This ended the action of the Conference in relation to matters considered by it upon their merits. In addition the Conference passed the following resolutions, for all of which the United States Delegation voted, referring various matters to the consideration of the Powers or to future Conferences. Upon the last five resolutions a few Powers abstained from voting.

The Second Resolution was as follows: The Conference taking into consideration the preliminary steps taken by the federal government of Switzerland for the revision of the Convention of Geneva, expresses the wish that there should be in a short time a meeting of a special conference having for its object the revision of that Convention.

This Resolution was voted unanimously.

Third: The Conference expresses the wish that the question of rights and duties of neutrals should be considered at another Conference.

Fourth: The Conference expresses the wish that questions relative to muskets and marine artillery, such as have been examined by it, should be made the subject of study on the part of the governments with a view of arriving at an agreement concerning the adoption of new types and calibers.

Fifth: The Conference expresses the wish that the governments, taking into account all the propositions made at this Conference, should study the possibility of an agreement concerning the limitation of armed forces on land and sea and of war budgets.

Sixth: The Conference expresses the wish that a proposition having for its object the declaration of immunity of private property in war on the high seas, should be referred for examination to another Conference.

Seventh: The Conference expresses the wish that the proposition of regulating the question of bombardment of ports, cities, or villages by a naval force, should be referred for examination to another Conference.

It will be observed that the conditions upon which Powers not represented at the Conference can adhere to the Convention for the Peaceful Regulation of International Conflicts is to "form the subject of a later agreement between the Contracting Powers." This provision reflects the outcome of a three days' debate in the Drafting Committee as to whether this Convention should be absolutely open, or open only with the consent of the Contracting Powers. England and Italy strenuously supported the latter view. It soon became apparent that, under the guise of general propositions, the Committee was discussing political questions, of great importance at least to certain Powers. Under these circumstances the representatives of the United States took no part in the discussion, but supported by their vote the view that the Convention, in its nature, involved reciprocal obligations; and also the conclusion that political questions had no place in the Conference, and must be left to be decided by the competent authorities of the Powers represented there.

It is to be regretted that this action excludes from immediate adherence to this Convention our sister Republics of Central and South America, with whom the United States is already in similar relations by the Pan-American Treaty. It is hoped that an arrangement will soon be made which will enable these States, if they so desire, to enter into the same relations as ourselves with the Powers represented at the Conference.

This report should not be closed without an acknowledgment of the great and constant courtesy of the Government of the Netherlands and all its representatives to the American Commission as well as to all the members of the Conference. In every way they have sought to aid us in our work and to make our stay agreeable to us. The accommodations they have provided for the Conference have enhanced its dignity and increased its efficiency.

It may also be well to put on record that from the entire Conference, without exception, we have constantly received marks of kindness, and that although so many nations with different interests were represented, there has not been in any session, whether of the Conference or of any of the committees or subcommittees, anything other than calm and courteous debate.

The text of the Final Act of the various Conventions and Declarations referred to therein, is appended to this report.

All of which is most respectfully submitted:
ANDREW D. WHITE, President,
SETH LOW,
STANFORD NEWEL,
A. T. MAHAN,
WILLIAM CROZIER,
FREDERICK W. HOLLS, Secretary.

References:
The Avalon Project at Yale Law School. www.yale.edu/lawweb/avalon/lawofwar/hague99/hag99-04.htm.

FINAL ACT OF THE INTERNATIONAL PEACE CONFERENCE; JULY 29, 1899

The International Peace Conference, convoked in the best interests of humanity by His Majesty the Emperor of All the Russias, assembled, on the invitation of the Government of Her Majesty the Queen of the Netherlands, in the Royal House in the Wood at The Hague on the 18th May, 1899.

The Powers enumerated in the following list took part in the Conference, to which they appointed the Delegates named below:

[List of Plenipotentiaries]

In a series of meetings, between the 18th May and the 29th July, 1899, in which the constant desire of the Delegates above mentioned has been to realize, in the fullest manner possible, the generous views of the August Initiator of the Conference and the intentions of their Governments, the Conference has agreed, for submission for signature by the Plenipotentiaries, on the text of the Conventions and Declarations enumerated below and annexed to the present Act:

I. Convention for the peaceful adjustment of international differences.

II. Convention regarding the laws and customs of war by land.

III. Convention for the adaptation to maritime warfare of the principles of the Geneva Convention of the 22d August, 1864.

IV. Three Declarations:

1. To prohibit the launching of projectiles and explosives from balloons or by other similar new methods.
2. To prohibit the use of projectiles the only object of which is the diffusion of asphyxiating or deleterious gases.
3. To prohibit the use of bullets which expand or flatten easily in the human body, such as bullets with a hard envelope, of which the envelope does not entirely cover the core, or is pierced with incisions.

These Conventions and Declarations shall form so many separate Acts. These Acts shall be dated this day, and may be signed up to the 31st December, 1899, by the Plenipotentiaries of the Powers represented at the International Peace Conference at The Hague.

Guided by the same sentiments, the Conference has adopted unanimously the following Resolution:

"The Conference is of opinion that the restriction of military charges, which are at present a heavy burden on the world, is extremely desirable for the increase of the material and moral welfare of mankind."

It has, besides, formulated the following wishes:

1. The Conference, taking into consideration the preliminary step taken by the Swiss Federal Government for the revision of the Geneva Convention, expresses the wish that steps may be shortly taken for the assembly of a Special Conference having for its object the revision of that convention.

This wish was voted unanimously.

2. The Conference expresses the wish that the questions of the rights and duties of neutrals may be inserted in the programme of a Conference in the near future.
3. The Conference expresses the wish that the questions with regard to rifles and naval guns, as considered by it, may be studied by the Governments with the object of coming to an agreement respecting the employment of new types and calibers.
4. The Conference expresses the wish that the Governments, taking into consideration the proposals made at the Conference, may examine the possibility of an agreement as to the limitation of armed forces by land and sea, and of war budgets.
5. The Conference expresses the wish that the proposal, which contemplates the declaration of the inviolability of private property in naval warfare, may be referred to a subsequent Conference for consideration.
6. The Conference expresses the wish that the proposal to settle the question of the bombardment of posts, towns, and villages by a naval force may be referred to a subsequent Conference for consideration.

The last five wishes were voted unanimously, saving some abstentions.

In faith of which, the Plenipotentiaries have signed the present Act, and have affixed their seals thereto.

Done at The Hague, 29th July, 1899, in one copy only, which shall be deposited in the Ministry for Foreign Affairs, and of which copies, duly certified, shall be delivered to all the Powers represented at the Conference.

[Signatures.]

Geneva Protocol (1925)

PROTOCOL FOR THE PROHIBITION OF THE USE IN WAR OF ASPHYXIATING, POISONOUS OR OTHER GASES, AND OF BACTERIOLOGICAL METHODS OF WARFARE

Opened for signature: 17 June 1925, entered into force: 8 February 1928.

The undersigned Plenipotentiaries, in the name of their respective governments:

Whereas the use in war of asphyxiating, poisonous or other gases, and of all analogous liquids, materials or devices, has been justly condemned by the general opinion of the civilised world; and

Whereas the prohibition of such use has been declared in Treaties to which the majority of Powers of the world are Parties; and

To the end that this prohibition shall be universally accepted as a part of International Law, binding alike the conscience and the practice of nations;

Declare:

That the High Contracting Parties, so far as they are not already Parties to Treaties prohibiting such use, accept this prohibition, agree to extend this prohibition to the use of bacteriological methods of warfare and agree to be bound as between themselves according to the terms of this declaration.

The High Contracting Parties will exert every effort to induce other States to accede to the present Protocol. Such accession will be notified to the Government of the French Republic, and by the latter to all signatories and acceding Powers, and will take effect on the date of the notification by the Government of the French Republic.

The present Protocol, of which the English and French texts are both authentic, shall be ratified as soon as possible. It shall bear to-day's date.

The ratifications of the present Protocol shall be addressed to the Government of the French Republic, which will at once notify the deposit of such ratification to each of the signatory and acceding Powers.

The instruments of ratification of and accession to the present Protocol will remain deposited in the archives of the Government of the French Republic.

The present Protocol will come into force for each signatory Power as from the date of deposit of its ratification, and, from that moment, each Power will be bound as regards other Powers which have already deposited their ratifications.

In witness whereof the Plenipotentiaries have signed the present Protocol.

Done at Geneva in a single copy, the seventeenth day of June, One Thousand Nine Hundred and Twenty-Five.

References:
The Harvard Sussex Program on CBW Armament and Arms Limitation. http://www.fas.harvard.edu/~hsp/1925.html

SIGNATORIES TO THE GENEVA PROTOCOL:

Afghanistan	1986
Albania	1989
Algeria	1992
Angola	1990
Antigua and Barbuda	1988
Argentina	1969
Australia	1930
Austria	1928
Bahrain	1988
Bangladesh	1989
Barbados	1976
Belarus	1970
Belgium	1928
Benin	1986
Bhutan	1979
Bolivia	1985
Brazil	1970
Bulgaria	1934
Burkina Faso	1971
Cambodia	1983
Cameroon	1989
Canada	1930
Cape Verde	1991
Central African Republic	1970
Chile	1935
China, People's Republic of	1952
Cote d'Ivoire	1970
Cuba	1966
Cyprus	1966
Czech Republic	1993
Denmark	1930
Dominican Republic	1970
Ecuador	1970
Egypt	1928
El Salvador	S
Equatorial Guinea	1989
Estonia	1931
Ethiopia	1935
Fiji	1973
Finland	1929
France	1926
Gambia	1966
Germany	1929
Ghana	1967
Greece	1931
Grenada	1989
Guatemala	1983
Guinea-Bissau	1989
Holy See	1966
Hungary	1952
Iceland	1967
India	1930
Indonesia	1971
Iran	1929
Iraq	1931
Ireland	1930
Israel	1969
Italy	1928
Jamaica	1970
Japan	1970
Jordan	1977
Kenya	1970
Korea, Democratic People's Republic of	1989
Korea, Republic of	1989
Kuwait	1971
Laos	1989
Latvia	1931
Lebanon	1969
Lesotho	1972
Liberia	1927
Libya	1971
Liechtenstein	1991
Lithuania	1933
Luxembourg	1936
Madagascar	1967
Malawi	1970
Malaysia	1970
Maldives	1966
Malta	1964
Mauritius	1970
Mexico	1932
Monaco	1967
Mongolia	1968
Morocco	1970
Nepal	1969
Netherlands	1930
New Zealand	1930
Nicaragua	1990
Niger	1967
Nigeria	1968
Norway	1932
Pakistan	1960
Panama	1970
Papua New Guinea	1980
Paraguay	1933
Peru	1985
Philippines	1973
Poland	1929
Portugal	1930
Qatar	1976
Romania	1929

Russia	1928
Rwanda	1964
St. Kitts and Nevis	1989
St. Lucia	1988
Saudi Arabia	1971
Senegal	1977
Sierra Leone	1967
Slovakia	1993
Solomon Islands	1981
South Africa	1930
Spain	1929
Sri Lanka	1954
Sudan	1980
Swaziland	1991
Sweden	1930
Switzerland	1932
Syria	1968
Tanzania	1963
Thailand	1931
Togo	1971
Tonga	1971
Trinidad and Tobago	1962
Tunisia	1967
Turkey	1929
Uganda	1965
United Kingdom	1930
United States	1975
Uruguay	1977
Venezuela	1928
Viet Nam	1980
Yemen	1971
Yugoslavia	1929

Biological and Toxin Weapons Convention (1972)

CONVENTION ON THE PROHIBITION OF THE DEVELOPMENT, PRODUCTION AND STOCKPILING OF BACTERIOLOGICAL (BIOLOGICAL) AND TOXIN WEAPONS AND ON THEIR DESTRUCTION

Signed at Washington, London, and Moscow April 10, 1972

Ratification advised by U.S. Senate December 16, 1974

Ratified by U.S. President January 22, 1975

U.S. ratification deposited at Washington, London, and Moscow March 26, 1975

Proclaimed by U.S. President March 26, 1975

Entered into force March 26, 1975

The States Parties to this Convention,

Determined to act with a view to achieving effective progress towards general and complete disarmament, including the prohibition and elimination of all types of weapons of mass destruction, and convinced that the prohibition of the development, production and stockpiling of chemical and bacteriological (biological) weapons and their elimination, through effective measures, will facilitate the achievement of general and complete disarmament under strict and effective international control,

Recognizing the important significance of the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on June 17, 1925, and conscious also of the contribution which the said Protocol has already made, and continues to make, to mitigating the horrors of war,

Reaffirming their adherence to the principles and objectives of that Protocol and calling upon all States to comply strictly with them,

Recalling that the General Assembly of the United Nations has repeatedly condemned all actions contrary to the principles and objectives of the Geneva Protocol of June 17, 1925,

Desiring to contribute to the strengthening of confidence between peoples and the general improvement of the international atmosphere,

Desiring also to contribute to the realization of the purposes and principles of the Charter of the United Nations,

Convinced of the importance and urgency of eliminating from the arsenals of States, through effective measures, such dangerous weapons of mass destruction as those using chemical or bacteriological (biological) agents,

Recognizing that an agreement on the prohibition of bacteriological (biological) and toxin weapons represents a first possible step towards the achievement of agreement on effective measures also for the prohibition of the development, production and stockpiling of chemical weapons, and determined to continue negotiations to that end,

Determined, for the sake of all mankind, to exclude completely the possibility of bacteriological (biological) agents and toxins being used as weapons,

Convinced that such use would be repugnant to the conscience of mankind and that no effort should be spared to minimize this risk,

Have agreed as follows:

ARTICLE I

Each State Party to this Convention undertakes never in any circumstances to develop, produce, stockpile or otherwise acquire or retain:

1. Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes;
2. Weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.

ARTICLE II

Each State Party to this Convention undertakes to destroy, or to divert to peaceful purposes, as soon as possible but not later than nine months after the entry into force of the Convention, all agents, toxins, weapons, equipment and means of delivery specified in article I of the Convention, which are in its possession or under its jurisdiction or control. In implementing the provisions of this article all necessary safety precautions shall be observed to protect populations and the environment.

ARTICLE III

Each State Party to this Convention undertakes not to transfer to any recipient whatsoever, directly or indirectly, and not in any way to assist, encourage, or induce any State, group of States or international organizations to manufacture or otherwise acquire any of the agents, toxins, weapons, equipment or means of delivery specified in article I of the Convention.

ARTICLE IV

Each State Party to this Convention shall, in accordance with its constitutional processes, take any necessary measures to prohibit and prevent the development, production, stockpiling, acquisition, or retention of the agents, toxins, weapons, equipment and means of delivery specified in article I of the Convention, within the territory of such State, under its jurisdiction or under its control anywhere.

ARTICLE V

The States Parties to this Convention undertake to consult one another and to cooperate in solving any problems which may arise in relation to the objective of, or in the application of the provisions of, the Convention. Consultation and cooperation pursuant to this article may also be undertaken through appropriate international procedures within the framework of the United Nations and in accordance with its Charter.

ARTICLE VI

1. Any State Party to this Convention which finds that any other State Party is acting in breach of obligations deriving from the provisions of the Convention may lodge a complaint with the Security Council of the United Nations. Such a complaint should include all possible evidence confirming its validity, as well as a request for its consideration by the Security Council.
2. Each State Party to this Convention undertakes to cooperate in carrying out any investigation which the Security Council may initiate, in accordance with the provisions of the Charter of the United Nations, on the basis of the complaint received by the Council. The Security Council shall inform the States Parties to the Convention of the results of the investigation.

ARTICLE VII

Each State Party to this Convention undertakes to provide or support assistance, in accordance with the United Nations Charter, to any Party to the Convention which so requests, if the Security Council decides that such Party has been exposed to danger as a result of violation of the Convention.

ARTICLE VIII

Nothing in this Convention shall be interpreted as in any way limiting or detracting from the obligations assumed by any State under the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on June 17, 1925.

ARTICLE IX

Each State Party to this Convention affirms the recognized objective of effective prohibition of chemical weapons and, to this end, undertakes to continue negotiations in good faith with a view to reaching early agreement on effective measures for the prohibition of their development, production and stockpiling and for their destruction, and on appropriate measures concerning equipment and means of delivery specifically designed for the production or use of chemical agents for weapons purposes.

ARTICLE X

1. The States Parties to this Convention undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the use of bacteriological (biological) agents and toxins for peaceful purposes. Parties to the Convention in a position to do so shall also cooperate in contributing individually or together with other States or international organizations to the further development and application of scientific discoveries in the field of bacteriology (biology) for prevention of disease, or for other peaceful purposes.
2. This Convention shall be implemented in a manner designed to avoid hampering the economic or technological development of States Parties to the Convention or international cooperation in the field of peaceful bacteriological (biological) activities, including the international exchange of bacteriological (biological) agents and toxins and equipment for the processing, use or production of bacteriological (biological) agents and toxins for peaceful purposes in accordance with the provisions of the Convention.

ARTICLE XI

Any State Party may propose amendments to this Convention. Amendments shall enter into force for each State Party accepting the amendments upon their acceptance by a majority of the States Parties to the Convention and thereafter for each remaining State Party on the date of acceptance by it.

ARTICLE XII

Five years after the entry into force of this Convention, or earlier if it is requested by a majority of Parties to the Convention by submitting a proposal to this effect to the Depositary Governments, a conference of States Parties to the Convention shall be held at Geneva, Switzerland, to review the operation of the Convention, with a view to assuring that the purposes of the preamble and the provisions of the Convention, including the provisions concerning negotiations on chemical weapons, are being realized. Such review shall take into account any new scientific and technological developments relevant to the Convention.

ARTICLE XIII

1. This Convention shall be of unlimited duration.
2. Each State Party to this Convention shall in exercising its national sovereignty have the right to withdraw from the Convention if it decides that extraordinary events, related to the subject matter of the Convention, have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other States Parties to the Convention and to the United Nations Security Council three months in advance. Such notice shall include a statement of the extraordinary events it regards as having jeopardized its supreme interests.

ARTICLE XIV

1. This Convention shall be open to all States for signature. Any State which does not sign the Convention before its entry into force in accordance with paragraph (3) of this Article may accede to it at any time.
2. This Convention shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of the United States of America, the United Kingdom of Great Britain and Northern Ireland and the Union of Soviet Socialist Republics, which are hereby designated the Depositary Governments.
3. This Convention shall enter into force after the deposit of instruments of ratification by twenty-two Governments, including the Governments designated as Depositaries of the Convention.
4. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Convention, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

5. The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification or of accession and the date of the entry into force of this Convention, and of the receipt of other notices.
6. This Convention shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations.

ARTICLE XV

This Convention, the English, Russian, French, Spanish and Chinese texts of which are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of the Convention shall be transmitted by the Depositary Governments to the Governments of the signatory and acceding states.

IN WITNESS WHEREOF the undersigned, duly authorized, have signed this Convention.

DONE in triplicate, at the cities of Washington, London and Moscow, this tenth day of April, one thousand nine hundred and seventy-two.

References:
U.S. Department of State, http://www.state.gov/t/ac/trt/4718pf.htm

PARTIES AND SIGNATORIES OF THE BIOLOGICAL WEAPONS CONVENTION

STATE (COUNTRY)

Afghanistan
Albania
Algeria
Argentina
Armenia
Australia
Austria (1)
Bahamas
Bahrain (1)
Bangladesh
Barbados
Belarus
Belgium
Belize
Benin
Bhutan
Bolivia
Bosnia Herzegovina
Botswana
Brazil
Brunei Darussalam(2)
Bulgaria
Burkina Faso
Cambodia (Kampuchea)
Canada
Cape Verde
Chile
China, People's Republic of (3)
Colombia
Congo
Costa Rica
Croatia
Cuba
Cyprus
Czech Republic
Denmark
Dominica (2)
Dominican Republic
Ecuador
El Salvador
Equatorial Guinea
Estonia
Ethiopia
Fiji
Finland
France
Gambia, The
Georgia
Germany
Ghana
Greece
Grenada
Guatemala
Guinea-Bissau
Honduras
Hungary
Iceland
India
Indonesia
Iran
Iraq
Ireland
Italy
Jamaica
Japan
Jordan
Kenya
Korea, Democratic People's Republic of
Korea, Republic of
Kuwait
Laos
Latvia
Lebanon

Lesotho
Libya
Liechtenstein
Lithuania
Luxembourg
Macedonia, Former Yugoslav Republic of
Malaysia (1)
Maldives
Malta
Mauritius
Mexico
Monaco
Mongolia
Netherlands (4)
New Zealand
Nicaragua
Niger
Nigeria
Norway
Oman
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Romania
Russian Federation
Rwanda
St. Kitts and Nevis
St. Lucia
St. Vincent and the Grenadines
San Marino
Sao Tome and Principe
Saudi Arabia
Senegal
Seychelles
Sierra Leone
Singapore
Slovak Republic
Slovenia
Solomon Islands (2)
South Africa
Spain
Sri Lanka
Suriname
Swaziland
Sweden
Switzerland
Thailand
Togo
Tonga
Tunisia
Turkey
Turkmenistan
Uganda
Ukraine
United Kingdom (6)
United States
Uruguay
Uzbekistan
Vanuatu
Venezuela
Vietnam
Yemen
Yugoslavia, Federal Republic of
Zaire
Zimbabwe

SIGNATORY COUNTRIES

Burundi
Central African Republic
Cote d'Ivoire
Egypt
Gabon
Guyana
Haiti
Liberia
Madagascar
Malawi
Mali
Morocco
Myanmar (Burma)
Nepal
Somalia
Syria
Tanzania
United Arab Emirates (5)

Chemical Weapons Convention[1] (1993)

PREAMBLE

The States Parties to this Convention,

Determined to act with a view to achieving effective progress towards general and complete disarmament under strict and effective international control, including the prohibition and elimination of all types of weapons of mass destruction,

Desiring to contribute to the realization of the purposes and principles of the Charter of the United Nations,

Recalling that the General Assembly of the United Nations has repeatedly condemned all actions contrary to the principles and objectives of the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on 17 June 1925 (the Geneva Protocol of 1925),

Recognizing that this Convention reaffirms principles and objectives of and obligations assumed under the Geneva Protocol of 1925, and the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction signed at London, Moscow and Washington on 10 April 1972,

Bearing in mind the objective contained in Article IX of the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction,

Determined for the sake of all mankind, to exclude completely the possibility of the use of chemical weapons, through the implementation of the provisions of this Convention, thereby complementing the obligations assumed under the Geneva Protocol of 1925,

Recognizing the prohibition, embodied in the pertinent agreements and relevant principles of international law, of the use of herbicides as a method of warfare,

Considering that achievements in the field of chemistry should be used exclusively for the benefit of mankind,

Desiring to promote free trade in chemicals as well as international cooperation and exchange of scientific and technical information in the field of chemical activities for purposes not prohibited under this Convention in order to enhance the economic and technological development of all States Parties,

Convinced that the complete and effective prohibition of the development, production, acquisition, stockpiling, retention, transfer and use of chemical weapons, and their destruction, represent a necessary step towards the achievement of these common objectives,

Have agreed as follows:

ARTICLE I

GENERAL OBLIGATIONS

1. Each State Party to this Convention undertakes never under any circumstances:

(a) To develop, produce, otherwise acquire, stockpile or retain chemical weapons, or transfer, directly or indirectly, chemical weapons to anyone;
(b) To use chemical weapons;
(c) To engage in any military preparations to use chemical weapons;
(d) To assist, encourage or induce, in any way, anyone to engage in any activity prohibited to a State Party under this Convention.

2. Each State Party undertakes to destroy chemical weapons it owns or possesses, or that are located in any place under its jurisdiction or control, in accordance with the provisions of this Convention.

3. Each State Party undertakes to destroy all chemical weapons it abandoned on the territory of another State Party, in accordance with the provisions of this Convention.

4. Each State Party undertakes to destroy any chemical weapons production facilities it owns or possesses, or that are located in any place under its jurisdiction or control, in accordance with the provisions of this Convention.

5. Each State Party undertakes not to use riot control agents as a method of warfare.

ARTICLE II

DEFINITIONS AND CRITERIA

For the purposes of this Convention:

1. "Chemical Weapons" means the following, together or separately:

(a) Toxic chemicals and their precursors, except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes;
(b) Munitions and devices, specifically designed to cause death or other harm through the toxic properties of those toxic chemicals specified in subparagraph (a), which would be released as a result of the employment of such munitions and devices;
(c) Any equipment specifically designed for use directly in connection with the employment of munitions and devices specified in subparagraph (b).

2. "Toxic Chemical" means:

Any chemical which through its chemical action on life processes can cause death, temporary incapacitation or permanent harm to humans or animals. This includes all such chemicals, regardless of their origin or of their method of production, and regardless of whether they are produced in facilities, in munitions or elsewhere.

(For the purpose of implementing this Convention, toxic chemicals which have been identified for the application of verification measures are listed in Schedules contained in the Annex on Chemicals.)

3. "Precursor" means:

Any chemical reactant which takes part at any stage in the production by whatever method of a toxic chemical. This includes any key component of a binary or multicomponent chemical system.

(For the purpose of implementing this Convention, precursors which have been identified for the application of verification measures are listed in Schedules contained in the Annex on Chemicals.)

4. "Key Component of Binary or Multicomponent Chemical Systems" (hereinafter referred to as "key component") means:

The precursor which plays the most important role in determining the toxic properties of the final product and reacts rapidly with other chemicals in the binary or multicomponent system.

5. "Old Chemical Weapons" means:

(a) Chemical weapons which were produced before 1925; or
(b) Chemical weapons produced in the period between 1925 and 1946 that have deteriorated to such extent that they can no longer be used as chemical weapons.

6. "Abandoned Chemical Weapons" means:

Chemical weapons, including old chemical weapons, abandoned by a State after 1 January 1925 on the territory of another State without the consent of the latter.

7. "Riot Control Agent" means:

Any chemical not listed in a Schedule, which can produce rapidly in humans sensory irritation or disabling physical effects which disappear within a short time following termination of exposure.

8. "Chemical Weapons Production Facility":

(a) Means any equipment, as well as any building housing such equipment, that was designed, constructed or used at any time since 1 January 1946:

(i). As part of the stage in the production of chemicals ("final technological stage") where the material flows would contain, when the equipment is in operation:
(1) Any chemical listed in Schedule 1 in the Annex on Chemicals; or
(2) Any other chemical that has no use, above 1 tonne per year on the territory of a State Party or in any other place under the jurisdiction or control of a State Party, for purposes not prohibited under this Convention, but can be used for chemical weapons purposes; or

(ii). For filling chemical weapons, including, inter alia, the filling of chemicals listed in Schedule 1 into munitions, devices or bulk storage containers; the filling of chemicals into containers that form part of assembled binary munitions and devices or into chemical submunitions that form part of assembled unitary munitions and devices, and the loading of the containers and chemical submunitions into the respective munitions and devices;

(b) Does not mean:

(i). Any facility having a production capacity for synthesis of chemicals specified in subparagraph (a) (i) that is less than 1 tonne;

(ii). Any facility in which a chemical specified in subparagraph (a) (i) is or was produced as an unavoidable by-product of activities for purposes not prohibited under this Convention, provided that the chemical does not exceed 3 per cent of the total product and that the facility is subject to declaration and inspection under the Annex on Implementation and Verification (hereinafter referred to as "Verification Annex"); or

(iii). The single small-scale facility for production of chemicals listed in Schedule 1 for purposes not prohibited under this Convention as referred to in Part VI of the Verification Annex.

9. "Purposes Not Prohibited Under this Convention" means

(a) Industrial, agricultural, research, medical, pharmaceutical or other peaceful purposes;
(b) Protective purposes, namely those purposes directly related to protection against toxic chemicals and to protection against chemical weapons;
(c) Military purposes not connected with the use of chemical weapons and not dependent on the use of the toxic properties of chemicals as a method of warfare;
(d) Law enforcement including domestic riot control purposes.

10. "Production Capacity" means:

The annual quantitative potential for manufacturing a specific chemical based on the technological process actually used or, if the process is not yet operational, planned to be used at the relevant facility. It shall be deemed to be equal to the nameplate capacity or, if the nameplate capacity is not available, to the design capacity. The nameplate capacity is the product output under conditions optimized for maximum quantity for the production facility, as demonstrated by one or more test-runs. The design capacity is the corresponding theoretically calculated product output.

11. "Organization" means the Organization for the Prohibition of Chemical Weapons established pursuant to Article VIII of this Convention.

12. For the purposes of Article VI:

(a) "Production" of a chemical means its formation through chemical reaction;
(b) "Processing" of a chemical means a physical process, such as formulation, extraction and purification, in which a chemical is not converted into another chemical;
(c) "Consumption" of a chemical means its conversion into another chemical via a chemical reaction.

ARTICLE III

DECLARATIONS

1. Each State Party shall submit to the Organization, not later than 30 days after this Convention enters into force for it, the following declarations, in which it shall:

(a) With respect to chemical weapons:

(i) Declare whether it owns or possesses any chemical weapons, or whether there are any chemical weapons located in any place under its jurisdiction or control;
(ii) Specify the precise location, aggregate quantity and detailed inventory of chemical weapons it owns or possesses, or that are located in any place under its jurisdiction or control, in accordance with Part IV (A), paragraphs 1 to 3, of the Verification Annex, except for those chemical weapons referred to in sub-subparagraph (iii);
(iii) Report any chemical weapons on its territory that are owned and possessed by another State and located in any place under the jurisdiction or control of another State, in accordance with Part IV (A), paragraph 4, of the Verification Annex;
(iv) Declare whether it has transferred or received, directly or indirectly, any chemical weapons since 1 January 1946 and specify the transfer or receipt of such weapons, in accordance with Part IV (A), paragraph 5, of the Verification Annex;
(v) Provide its general plan for destruction of chemical weapons that it owns or possesses, or that are located in any place under its jurisdiction or control, in accordance with Part IV (A), paragraph 6, of the Verification Annex;

(b) With respect to old chemical weapons and abandoned chemical weapons:

(i) Declare whether it has on its territory old chemical weapons and provide all available information in accordance with Part IV (B), paragraph 3, of the Verification Annex;
(ii) Declare whether there are abandoned chemical weapons on its territory and provide all available information in accordance with Part IV (B), paragraph 8, of the Verification Annex;
(iii) Declare whether it has abandoned chemical weapons on the territory of other States and provide all available information in accordance with Part IV (B), paragraph 10, of the Verification Annex;

(c) With respect to chemical weapons production facilities:

(i) Declare whether it has or has had any chemical weapons production facility under its ownership or possession, or that is or has been located in any place under its jurisdiction or control at any time since 1 January 1946;
(ii) Specify any chemical weapons production facility it has or has had under its ownership or possession or that is or has been located in any place under its jurisdiction or control at any time since 1 January 1946, in accordance with Part V, paragraph 1, of the Verification Annex, except for those facilities referred to in sub-subparagraph (iii);
(iii) Report any chemical weapons production facility on its territory that another State has or has had under its ownership and possession and that is or has been located in any place

under the jurisdiction or control of another State at any time since 1 January 1946, in accordance with Part V, paragraph 2, of the Verification Annex;

(iv) Declare whether it has transferred or received, directly or indirectly, any equipment for the production of chemical weapons since 1 January 1946 and specify the transfer or receipt of such equipment, in accordance with Part V, paragraphs 3 to 5, of the Verification Annex;

(v) Provide its general plan for destruction of any chemical weapons production facility it owns or possesses, or that is located in any place under its jurisdiction or control, in accordance with Part V, paragraph 6, of the Verification Annex;

(vi) Specify actions to be taken for closure of any chemical weapons production facility it owns or possesses, or that is located in any place under its jurisdiction or control, in accordance with Part V, paragraph 1 (i), of the Verification Annex;

(vii) Provide its general plan for any temporary conversion of any chemical weapons production facility it owns or possesses, or that is located in any place under its jurisdiction or control, into a chemical weapons destruction facility, in accordance with Part V, paragraph 7, of the Verification Annex;

(d) With respect to other facilities: Specify the precise location, nature and general scope of activities of any facility or establishment under its ownership or possession, or located in any place under its jurisdiction or control, and that has been designed, constructed or used since 1 January 1946 primarily for development of chemical weapons. Such declaration shall include, inter alia, laboratories and test and evaluation sites;

(e) With respect to riot control agents: Specify the chemical name, structural formula and Chemical Abstracts Service (CAS) registry number, if assigned, of each chemical it holds for riot control purposes. This declaration shall be updated not later than 30 days after any change becomes effective.

2. The provisions of this Article and the relevant provisions of Part IV of the Verification Annex shall not, at the discretion of a State Party, apply to chemical weapons buried on its territory before 1 January 1977 and which remain buried, or which had been dumped at sea before 1 January 1985.

ARTICLE IV

CHEMICAL WEAPONS

1. The provisions of this Article and the detailed procedures for its implementation shall apply to all chemical weapons owned or possessed by a State Party, or that are located in any place under its jurisdiction or control, except old chemical weapons and abandoned chemical weapons to which Part IV (B) of the Verification Annex applies.

2. Detailed procedures for the implementation of this Article are set forth in the Verification Annex.

3. All locations at which chemical weapons specified in paragraph 1 are stored or destroyed shall be subject to systematic verification through on-site inspection and monitoring with on-site instruments, in accordance with Part IV (A) of the Verification Annex.

4. Each State Party shall, immediately after the declaration under Article III,

paragraph 1 (a), has been submitted, provide access to chemical weapons specified in paragraph 1 for the purpose of systematic verification of the declaration through on-site inspection. Thereafter, each State Party shall not remove any of these chemical weapons, except to a chemical weapons destruction facility. It shall provide access to such chemical weapons, for the purpose of systematic on-site verification.

5. Each State Party shall provide access to any chemical weapons destruction facilities and their storage areas, that it owns or possesses, or that are located in any place under its jurisdiction or control, for the purpose of systematic verification through on-site inspection and monitoring with on-site instruments.

6. Each State Party shall destroy all chemical weapons specified in paragraph 1 pursuant to the Verification Annex and in accordance with the agreed rate and sequence of destruction (hereinafter referred to as "order of destruction"). Such destruction shall begin not later than two years after this Convention enters into force for it and shall finish not later than 10 years after entry into force of this Convention. A State Party is not precluded from destroying such chemical weapons at a faster rate.

7. Each State Party shall:

(a) Submit detailed plans for the destruction of chemical weapons specified in paragraph 1 not later than 60 days before each annual destruction period begins, in accordance with Part IV (A), paragraph 29, of the Verification Annex; the detailed plans shall encompass all stocks to be destroyed during the next annual destruction period;

(b) Submit declarations annually regarding the implementation of its plans for destruction of chemical weapons specified in paragraph 1, not later

than 60 days after the end of each annual destruction period; and
(c) Certify, not later than 30 days after the destruction process has been completed, that all chemical weapons specified in paragraph 1 have been destroyed.

8. If a State ratifies or accedes to this Convention after the 10-year period for destruction set forth in paragraph 6, it shall destroy chemical weapons specified in paragraph 1 as soon as possible. The order of destruction and procedures for stringent verification for such a State Party shall be determined by the Executive Council.

9. Any chemical weapons discovered by a State Party after the initial declaration of chemical weapons shall be reported, secured and destroyed in accordance with Part IV (A) of the Verification Annex.

10. Each State Party, during transportation, sampling, storage and destruction of chemical weapons, shall assign the highest priority to ensuring the safety of people and to protecting the environment. Each State Party shall transport, sample, store and destroy chemical weapons in accordance with its national standards for safety and emissions.

11. Any State Party which has on its territory chemical weapons that are owned or possessed by another State, or that are located in any place under the jurisdiction or control of another State, shall make the fullest efforts to ensure that these chemical weapons are removed from its territory not later than one year after this Convention enters into force for it. If they are not removed within one year, the State Party may request the Organization and other States Parties to provide assistance in the destruction of these chemical weapons.

12. Each State Party undertakes to cooperate with other States Parties that request information or assistance on a bilateral basis or through the Technical Secretariat regarding methods and technologies for the safe and efficient destruction of chemical weapons.

13. In carrying out verification activities pursuant to this Article and Part IV (A) of the Verification Annex, the Organization shall consider measures to avoid unnecessary duplication of bilateral or multilateral agreements on verification of chemical weapons storage and their destruction among States Parties.

To this end, the Executive Council shall decide to limit verification to measures complementary to those undertaken pursuant to such a bilateral or multilateral agreement, if it considers that:

(a) Verification provisions of such an agreement are consistent with the verification provisions of this Article and Part IV (A) of the Verification Annex;
(b) Implementation of such an agreement provides for sufficient assurance of compliance with the relevant provisions of this Convention; and
(c) Parties to the bilateral or multilateral agreement keep the Organization fully informed about their verification activities.

14. If the Executive Council takes a decision pursuant to paragraph 13, the Organization shall have the right to monitor the implementation of the bilateral or multilateral agreement.

15. Nothing in paragraphs 13 and 14 shall affect the obligation of a State Party to provide declarations pursuant to Article III, this Article and Part IV (A) of the Verification Annex.

16. Each State Party shall meet the costs of destruction of chemical weapons it is obliged to destroy. It shall also meet the costs of verification of storage and destruction of these chemical weapons unless the Executive Council decides otherwise. If the Executive Council decides to limit verification measures of the Organization pursuant to paragraph 13, the costs of complementary verification and monitoring by the Organization shall be paid in accordance with the United Nations scale of assessment, as specified in Article VIII, paragraph 7.

17. The provisions of this Article and the relevant provisions of Part IV of the Verification Annex shall not, at the discretion of a State Party, apply to chemical weapons buried on its territory before 1 January 1977 and which remain buried, or which had been dumped at sea before 1 January 1985.

ARTICLE V

CHEMICAL WEAPONS PRODUCTION FACILITIES

1. The provisions of this Article and the detailed procedures for its implementation shall apply to any and all chemical weapons production facilities owned or possessed by a State Party, or that are located in any place under its jurisdiction or control.

2. Detailed procedures for the implementation of this Article are set forth in the Verification Annex.

3. All chemical weapons production facilities specified in paragraph 1 shall be subject to systematic verification through on-site inspection and monitoring with on-site instruments in accordance with Part V of the Verification Annex.

4. Each State Party shall cease immediately all activity at chemical weapons production facilities specified in paragraph 1, except activity required for closure.

5. No State Party shall construct any new chemical weapons production facilities or modify any existing

facilities for the purpose of chemical weapons production or for any other activity prohibited under this Convention.

6. Each State Party shall, immediately after the declaration under Article III, paragraph 1 (c), has been submitted, provide access to chemical weapons production facilities specified in paragraph 1, for the purpose of systematic verification of the declaration through on-site inspection.

7. Each State Party shall:

(a) Close, not later than 90 days after this Convention enters into force for it, all chemical weapons production facilities specified in paragraph 1, in accordance with Part V of the Verification Annex, and give notice thereof; and
(b) Provide access to chemical weapons production facilities specified in paragraph 1, subsequent to closure, for the purpose of systematic verification through on-site inspection and monitoring with on-site instruments in order to ensure that the facility remains closed and is subsequently destroyed.

8. Each State Party shall destroy all chemical weapons production facilities specified in paragraph 1 and related facilities and equipment, pursuant to the Verification Annex and in accordance with an agreed rate and sequence of destruction (hereinafter referred to as "order of destruction"). Such destruction shall begin not later than one year after this Convention enters into force for it, and shall finish not later than 10 years after entry into force of this Convention. A State Party is not precluded from destroying such facilities at a faster rate.

9. Each State Party shall:

(a) Submit detailed plans for destruction of chemical weapons production facilities specified in paragraph 1, not later than 180 days before the destruction of each facility begins;
(b) Submit declarations annually regarding the implementation of its plans for the destruction of all chemical weapons production facilities specified in paragraph 1, not later than 90 days after the end of each annual destruction period; and
(c) Certify, not later than 30 days after the destruction process has been completed, that all chemical weapons production facilities specified in paragraph 1 have been destroyed.

10. If a State ratifies or accedes to this Convention after the 10-year period for destruction set forth in paragraph 8, it shall destroy chemical weapons production facilities specified in paragraph 1 as soon as possible. The order of destruction and procedures for stringent verification for such a State Party shall be determined by the Executive Council.

11. Each State Party, during the destruction of chemical weapons production facilities, shall assign the highest priority to ensuring the safety of people and to protecting the environment. Each State Party shall destroy chemical weapons production facilities in accordance with its national standards for safety and emissions.

12. Chemical weapons production facilities specified in paragraph 1 may be temporarily converted for destruction of chemical weapons in accordance with Part V, paragraphs 18 to 25, of the Verification Annex. Such a converted facility must be destroyed as soon as it is no longer in use for destruction of chemical weapons but, in any case, not later than 10 years after entry into force of this Convention.

13. A State Party may request, in exceptional cases of compelling need, permission to use a chemical weapons production facility specified in paragraph 1 for purposes not prohibited under this Convention. Upon the recommendation of the Executive Council, the Conference of the States Parties shall decide whether or not to approve the request and shall establish the conditions upon which approval is contingent in accordance with Part V, Section D, of the Verification Annex.

14. The chemical weapons production facility shall be converted in such a manner that the converted facility is not more capable of being reconverted into a chemical weapons production facility than any other facility used for industrial, agricultural, research, medical, pharmaceutical or other peaceful purposes not involving chemicals listed in Schedule 1.

15. All converted facilities shall be subject to systematic verification through on-site inspection and monitoring with on-site instruments in accordance with Part V, Section D, of the Verification Annex.

16. In carrying out verification activities pursuant to this Article and Part V of the Verification Annex, the Organization shall consider measures to avoid unnecessary duplication of bilateral or multilateral agreements on verification of chemical weapons production facilities and their destruction among States Parties.

To this end, the Executive Council shall decide to limit the verification to measures complementary to those undertaken pursuant to such a bilateral or multilateral agreement, if it considers that:

(a) Verification provisions of such an agreement are consistent with the verification provisions of this Article and Part V of the Verification Annex;
(b) Implementation of the agreement provides for sufficient assurance of compliance with the relevant provisions of this Convention; and

(c) Parties to the bilateral or multilateral agreement keep the Organization fully informed about their verification activities.

17. If the Executive Council takes a decision pursuant to paragraph 16, the Organization shall have the right to monitor the implementation of the bilateral or multilateral agreement.

18. Nothing in paragraphs 16 and 17 shall affect the obligation of a State Party to make declarations pursuant to Article III, this Article and Part V of the Verification Annex.

19. Each State Party shall meet the costs of destruction of chemical weapons production facilities it is obliged to destroy. It shall also meet the costs of verification under this Article unless the Executive Council decides otherwise. If the Executive Council decides to limit verification measures of the Organization pursuant to paragraph 16, the costs of complementary verification and monitoring by the Organization shall be paid in accordance with the United Nations scale of assessment, as specified in Article VIII, paragraph 7.

ARTICLE VI

ACTIVITIES NOT PROHIBITED UNDER THIS CONVENTION

1. Each State Party has the right, subject to the provisions of this Convention, to develop, produce, otherwise acquire, retain, transfer and use toxic chemicals and their precursors for purposes not prohibited under this Convention.

2. Each State Party shall adopt the necessary measures to ensure that toxic chemicals and their precursors are only developed, produced, otherwise acquired, retained, transferred, or used within its territory or in any other place under its jurisdiction or control for purposes not prohibited under this Convention. To this end, and in order to verify that activities are in accordance with obligations under this Convention, each State Party shall subject toxic chemicals and their precursors listed in Schedules 1, 2 and 3 of the Annex on Chemicals, facilities related to such chemicals, and other facilities as specified in the Verification Annex, that are located on its territory or in any other place under its jurisdiction or control, to verification measures as provided in the Verification Annex.

3. Each State Party shall subject chemicals listed in Schedule 1 (hereinafter referred to as "Schedule 1 chemicals") to the prohibitions on production, acquisition, retention, transfer and use as specified in Part VI of the Verification Annex. It shall subject Schedule 1 chemicals and facilities specified in Part VI of the Verification Annex to systematic verification through on-site inspection and monitoring with on-site instruments in accordance with that Part of the Verification Annex.

4. Each State Party shall subject chemicals listed in Schedule 2 (hereinafter referred to as "Schedule 2 chemicals") and facilities specified in Part VII of the Verification Annex to data monitoring and on-site verification in accordance with that Part of the Verification Annex.

5. Each State Party shall subject chemicals listed in Schedule 3 (hereinafter referred to as "Schedule 3 chemicals") and facilities specified in Part VIII of the Verification Annex to data monitoring and on-site verification in accordance with that Part of the Verification Annex.

6. Each State Party shall subject facilities specified in Part IX of the Verification Annex to data monitoring and eventual on-site verification in accordance with that Part of the Verification Annex unless decided otherwise by the Conference of the States Parties pursuant to Part IX, paragraph 22, of the Verification Annex.

7. Not later than 30 days after this Convention enters into force for it, each State Party shall make an initial declaration on relevant chemicals and facilities in accordance with the Verification Annex.

8. Each State Party shall make annual declarations regarding the relevant chemicals and facilities in accordance with the Verification Annex.

9. For the purpose of on-site verification, each State Party shall grant to the inspectors access to facilities as required in the Verification Annex.

10. In conducting verification activities, the Technical Secretariat shall avoid undue intrusion into the State Party's chemical activities for purposes not prohibited under this Convention and, in particular, abide by the provisions set forth in the Annex on the Protection of Confidential Information (hereinafter referred to as "Confidentiality Annex").

11. The provisions of this Article shall be implemented in a manner which avoids hampering the economic or technological development of States Parties, and international cooperation in the field of chemical activities for purposes not prohibited under this Convention including the international exchange of scientific and technical information and chemicals and equipment for the production, processing or use of chemicals for purposes not prohibited under this Convention.

ARTICLE VII

NATIONAL IMPLEMENTATION MEASURES

General undertakings

1. Each State Party shall, in accordance with its constitutional processes, adopt the necessary measures to implement its obligations under this Convention. In particular, it shall:

(a) Prohibit natural and legal persons anywhere on its territory or in any other place under its jurisdiction as recognized by international law from undertaking any activity prohibited to a State Party under this Convention, including enacting penal legislation with respect to such activity;
(b) Not permit in any place under its control any activity prohibited to a State Party under this Convention; and
(c) Extend its penal legislation enacted under subparagraph (a) to any activity prohibited to a State Party under this Convention undertaken anywhere by natural persons, possessing its nationality, in conformity with international law.

2. Each State Party shall cooperate with other States Parties and afford the appropriate form of legal assistance to facilitate the implementation of the obligations under paragraph 1.

3. Each State Party, during the implementation of its obligations under this Convention, shall assign the highest priority to ensuring the safety of people and to protecting the environment, and shall cooperate as appropriate with other States Parties in this regard.

Relations between the State Party and the Organization

4. In order to fulfil its obligations under this Convention, each State Party shall designate or establish a National Authority to serve as the national focal point for effective liaison with the Organization and other States Parties. Each State Party shall notify the Organization of its National Authority at the time that this Convention enters into force for it.

5. Each State Party shall inform the Organization of the legislative and administrative measures taken to implement this Convention.

6. Each State Party shall treat as confidential and afford special handling to information and data that it receives in confidence from the Organization in connection with the implementation of this Convention. It shall treat such information and data exclusively in connection with its rights and obligations under this Convention and in accordance with the provisions set forth in the Confidentiality Annex.

7. Each State Party undertakes to cooperate with the Organization in the exercise of all its functions and in particular to provide assistance to the Technical Secretariat.

ARTICLE VIII

THE ORGANIZATION

A. General Provisions

1. The States Parties to this Convention hereby establish the Organization for the Prohibition of Chemical Weapons to achieve the object and purpose of this Convention, to ensure the implementation of its provisions, including those for international verification of compliance with it, and to provide a forum for consultation and cooperation among States Parties.

2. All States Parties to this Convention shall be members of the Organization. A State Party shall not be deprived of its membership in the Organization.

3. The seat of the Headquarters of the Organization shall be The Hague, Kingdom of the Netherlands.

4. There are hereby established as the organs of the Organization: the Conference of the States Parties, the Executive Council, and the Technical Secretariat.

5. The Organization shall conduct its verification activities provided for under this Convention in the least intrusive manner possible consistent with the timely and efficient accomplishment of their objectives. It shall request only the information and data necessary to fulfil its responsibilities under this Convention. It shall take every precaution to protect the confidentiality of information on civil and military activities and facilities coming to its knowledge in the implementation of this Convention and, in particular, shall abide by the provisions set forth in the Confidentiality Annex.

6. In undertaking its verification activities the Organization shall consider measures to make use of advances in science and technology.

7. The costs of the Organization's activities shall be paid by States Parties in accordance with the United Nations scale of assessment adjusted to take into account differences in membership between the United Nations and this Organization, and subject to the provisions of Articles IV and V. Financial contributions of States Parties to the Preparatory Commission shall be deducted in an appropriate way from their contributions to the regular budget. The budget of the Organization shall comprise two separate chapters, one relating to administrative and other costs, and one relating to verification costs.

8. A member of the Organization which is in arrears in the payment of its financial contribution to the Organization shall have no vote in the Organization if the amount of its arrears equals or exceeds the amount of the contribution due from it for the preceding two full years. The Conference of the States Parties may, nevertheless, permit such a member to vote if it is satisfied that the failure to pay is due to conditions beyond the control of the member.

B. The Conference of the States Parties

Composition, procedures and decision-making

9. The Conference of the States Parties (hereinafter referred to as "the Conference") shall be composed of all members of this Organization. Each member shall have

one representative in the Conference, who may be accompanied by alternates and advisers.

10. The first session of the Conference shall be convened by the depositary not later than 30 days after the entry into force of this Convention.

11. The Conference shall meet in regular sessions which shall be held annually unless it decides otherwise.

12. Special sessions of the Conference shall be convened:

(a) When decided by the Conference;
(b) When requested by the Executive Council;
(c) When requested by any member and supported by one third of the members; or
(d) In accordance with paragraph 22 to undertake reviews of the operation of this Convention.

Except in the case of subparagraph (d), the special session shall be convened not later than 30 days after receipt of the request by the Director-General of the Technical Secretariat, unless specified otherwise in the request.

13. The Conference shall also be convened in the form of an Amendment Conference in accordance with Article XV, paragraph 2.

14. Sessions of the Conference shall take place at the seat of the Organization unless the Conference decides otherwise.

15. The Conference shall adopt its rules of procedure. At the beginning of each regular session, it shall elect its Chairman and such other officers as may be required. They shall hold office until a new Chairman and other officers are elected at the next regular session.

16. A majority of the members of the Organization shall constitute a quorum for the Conference.

17. Each member of the Organization shall have one vote in the Conference.

18. The Conference shall take decisions on questions of procedure by a simple majority of the members present and voting. Decisions on matters of substance should be taken as far as possible by consensus. If consensus is not attainable when an issue comes up for decision, the Chairman shall defer any vote for 24 hours and during this period of deferment shall make every effort to facilitate achievement of consensus, and shall report to the Conference before the end of this period. If consensus is not possible at the end of 24 hours, the Conference shall take the decision by a two-thirds majority of members present and voting unless specified otherwise in this Convention. When the issue arises as to whether the question is one of substance or not, that question shall be treated as a matter of substance unless otherwise decided by the Conference by the majority required for decisions on matters of substance.

Powers and functions

19. The Conference shall be the principal organ of the Organization. It shall consider any questions, matters or issues within the scope of this Convention, including those relating to the powers and functions of the Executive Council and the Technical Secretariat. It may make recommendations and take decisions on any questions, matters or issues related to this Convention raised by a State Party or brought to its attention by the Executive Council.

20. The Conference shall oversee the implementation of this Convention, and act in order to promote its object and purpose. The Conference shall review compliance with this Convention. It shall also oversee the activities of the Executive Council and the Technical Secretariat and may issue guidelines in accordance with this Convention to either of them in the exercise of their functions.

21. The Conference shall:

(a) Consider and adopt at its regular sessions the report, programme and budget of the Organization, submitted by the Executive Council, as well as consider other reports;
(b) Decide on the scale of financial contributions to be paid by States Parties in accordance with paragraph 7;
(c) Elect the members of the Executive Council;
(d) Appoint the Director-General of the Technical Secretariat (hereinafter referred to as "the Director-General");
(e) Approve the rules of procedure of the Executive Council submitted by the latter;
(f) Establish such subsidiary organs as it finds necessary for the exercise of its functions in accordance with this Convention;
(g) Foster international cooperation for peaceful purposes in the field of chemical activities;
(h) Review scientific and technological developments that could affect the operation of this Convention and, in this context, direct the Director-General to establish a Scientific Advisory Board to enable him, in the performance of his functions, to render specialized advice in areas of science and technology relevant to this Convention, to the Conference, the Executive Council or States Parties. The Scientific Advisory Board shall be composed of independent experts appointed in accordance with terms of reference adopted by the Conference;
(i) Consider and approve at its first session any draft agreements, provisions and guidelines developed by the Preparatory Commission;
(j) Establish at its first session the voluntary fund for assistance in accordance with Article X;

(k) Take the necessary measures to ensure compliance with this Convention and to redress and remedy any situation which contravenes the provisions of this Convention, in accordance with Article XII.

22. The Conference shall not later than one year after the expiry of the fifth and the tenth year after the entry into force of this Convention, and at such other times within that time period as may be decided upon, convene in special sessions to undertake reviews of the operation of this Convention. Such reviews shall take into account any relevant scientific and technological developments. At intervals of five years thereafter, unless otherwise decided upon, further sessions of the Conference shall be convened with the same objective.

C. The Executive Council

Composition, procedure and decision-making

23. The Executive Council shall consist of 41 members. Each State Party shall have the right, in accordance with the principle of rotation, to serve on the Executive Council. The members of the Executive Council shall be elected by the Conference for a term of two years. In order to ensure the effective functioning of this Convention, due regard being specially paid to equitable geographical distribution, to the importance of chemical industry, as well as to political and security interests, the Executive Council shall be composed as follows:

(a) Nine States Parties from Africa to be designated by States Parties located in this region. As a basis for this designation it is understood that, out of these nine States Parties, three members shall, as a rule, be the States Parties with the most significant national chemical industry in the region as determined by internationally reported and published data; in addition, the regional group shall agree also to take into account other regional factors in designating these three members;
(b) Nine States Parties from Asia to be designated by States Parties located in this region. As a basis for this designation it is understood that, out of these nine States Parties, four members shall, as a rule, be the States Parties with the most significant national chemical industry in the region as determined by internationally reported and published data; in addition, the regional group shall agree also to take into account other regional factors in designating these four members;
(c) Five States Parties from Eastern Europe to be designated by States Parties located in this region. As a basis for this designation it is understood that, out of these five States Parties, one member shall, as a rule, be the State Party with the most significant national chemical industry in the region as determined by internationally reported and published data; in addition, the regional group shall agree also to take into account other regional factors in designating this one member;
(d) Seven States Parties from Latin America and the Caribbean to be designated by States Parties located in this region. As a basis for this designation it is understood that, out of these seven States Parties, three members shall, as a rule, be the States Parties with the most significant national chemical industry in the region as determined by internationally reported and published data; in addition, the regional group shall agree also to take into account other regional factors in designating these three members;
(e) Ten States Parties from among Western European and other States to be designated by States Parties located in this region. As a basis for this designation it is understood that, out of these 10 States Parties, 5 members shall, as a rule, be the States Parties with the most significant national chemical industry in the region as determined by internationally reported and published data; in addition, the regional group shall agree also to take into account other regional factors in designating these five members;
(f) One further State Party to be designated consecutively by States Parties located in the regions of Asia and Latin America and the Caribbean. As a basis for this designation it is understood that this State Party shall be a rotating member from these regions.

24. For the first election of the Executive Council 20 members shall be elected for a term of one year, due regard being paid to the established numerical proportions as described in paragraph 23.

25. After the full implementation of Articles IV and V the Conference may, upon the request of a majority of the members of the Executive Council, review the composition of the Executive Council taking into account developments related to the principles specified in paragraph 23 that are governing its composition.

26. The Executive Council shall elaborate its rules of procedure and submit them to the Conference for approval.

27. The Executive Council shall elect its Chairman from among its members.

28. The Executive Council shall meet for regular sessions. Between regular sessions it shall meet as often as may be required for the fulfilment of its powers and functions.

29. Each member of the Executive Council shall have one vote. Unless otherwise specified in this Convention,

the Executive Council shall take decisions on matters of substance by a two-thirds majority of all its members. The Executive Council shall take decisions on questions of procedure by a simple majority of all its members. When the issue arises as to whether the question is one of substance or not, that question shall be treated as a matter of substance unless otherwise decided by the Executive Council by the majority required for decisions on matters of substance.

Powers and functions

30. The Executive Council shall be the executive organ of the Organization. It shall be responsible to the Conference. The Executive Council shall carry out the powers and functions entrusted to it under this Convention, as well as those functions delegated to it by the Conference. In so doing, it shall act in conformity with the recommendations, decisions and guidelines of the Conference and assure their proper and continuous implementation.

31. The Executive Council shall promote the effective implementation of, and compliance with, this Convention. It shall supervise the activities of the Technical Secretariat, cooperate with the National Authority of each State Party and facilitate consultations and cooperation among States Parties at their request.

32. The Executive Council shall:

(a) Consider and submit to the Conference the draft programme and budget of the Organization;
(b) Consider and submit to the Conference the draft report of the Organization on the implementation of this Convention, the report on the performance of its own activities and such special reports as it deems necessary or which the Conference may request;
(c) Make arrangements for the sessions of the Conference including the preparation of the draft agenda.

33. The Executive Council may request the convening of a special session of the Conference.

34. The Executive Council shall:

(a) Conclude agreements or arrangements with States and international organizations on behalf of the Organization, subject to prior approval by the Conference;
(b) Conclude agreements with States Parties on behalf of the Organization in connection with Article X and supervise the voluntary fund referred to in Article X;
(c) Approve agreements or arrangements relating to the implementation of verification activities, negotiated by the Technical Secretariat with States Parties.

35. The Executive Council shall consider any issue or matter within its competence affecting this Convention and its implementation, including concerns regarding compliance, and cases of non-compliance, and, as appropriate, inform States Parties and bring the issue or matter to the attention of the Conference.

36. In its consideration of doubts or concerns regarding compliance and cases of non-compliance, including, inter alia, abuse of the rights provided for under this Convention, the Executive Council shall consult with the States Parties involved and, as appropriate, request the State Party to take measures to redress the situation within a specified time. To the extent that the Executive Council considers further action to be necessary, it shall take, inter alia, one or more of the following measures:

(a) Inform all States Parties of the issue or matter;
(b) Bring the issue or matter to the attention of the Conference;
(c) Make recommendations to the Conference regarding measures to redress the situation and to ensure compliance.

The Executive Council shall, in cases of particular gravity and urgency, bring the issue or matter, including relevant information and conclusions, directly to the attention of the United Nations General Assembly and the United Nations Security Council. It shall at the same time inform all States Parties of this step.

D. The Technical Secretariat

37. The Technical Secretariat shall assist the Conference and the Executive Council in the performance of their functions. The Technical Secretariat shall carry out the verification measures provided for in this Convention. It shall carry out the other functions entrusted to it under this Convention as well as those functions delegated to it by the Conference and the Executive Council.

38. The Technical Secretariat shall:

(a) Prepare and submit to the Executive Council the draft programme and budget of the Organization;
(b) Prepare and submit to the Executive Council the draft report of the Organization on the implementation of this Convention and such other reports as the Conference or the Executive Council may request;
(c) Provide administrative and technical support to the Conference, the Executive Council and subsidiary organs;
(d) Address and receive communications on behalf of the Organization to and from States Parties on matters pertaining to the implementation of this Convention;

(e) Provide technical assistance and technical evaluation to States Parties in the implementation of the provisions of this Convention, including evaluation of scheduled and unscheduled chemicals.

39. The Technical Secretariat shall:

(a) Negotiate agreements or arrangements relating to the implementation of verification activities with States Parties, subject to approval by the Executive Council;
(b) Not later than 180 days after entry into force of this Convention, coordinate the establishment and maintenance of permanent stockpiles of emergency and humanitarian assistance by States Parties in accordance with Article X, paragraphs 7 (b) and (c). The Technical Secretariat may inspect the items maintained for serviceability. Lists of items to be stockpiled shall be considered and approved by the Conference pursuant to paragraph 21 (i) above;
(c) Administer the voluntary fund referred to in Article X, compile declarations made by the States Parties and register, when requested, bilateral agreements concluded between States Parties or between a State Party and the Organization for the purposes of Article X.

40. The Technical Secretariat shall inform the Executive Council of any problem that has arisen with regard to the discharge of its functions, including doubts, ambiguities or uncertainties about compliance with this Convention that have come to its notice in the performance of its verification activities and that it has been unable to resolve or clarify through its consultations with the State Party concerned.

41. The Technical Secretariat shall comprise a Director-General, who shall be its head and chief administrative officer, inspectors and such scientific, technical and other personnel as may be required.

42. The Inspectorate shall be a unit of the Technical Secretariat and shall act under the supervision of the Director-General.

43. The Director-General shall be appointed by the Conference upon the recommendation of the Executive Council for a term of four years, renewable for one further term, but not thereafter.

44. The Director-General shall be responsible to the Conference and the Executive Council for the appointment of the staff and the organization and functioning of the Technical Secretariat. The paramount consideration in the employment of the staff and in the determination of the conditions of service shall be the necessity of securing the highest standards of efficiency, competence and integrity. Only citizens of States Parties shall serve as the Director-General, as inspectors or as other members of the professional and clerical staff. Due regard shall be paid to the importance of recruiting the staff on as wide a geographical basis as possible. Recruitment shall be guided by the principle that the staff shall be kept to a minimum necessary for the proper discharge of the responsibilities of the Technical Secretariat.

45. The Director-General shall be responsible for the organization and functioning of the Scientific Advisory Board referred to in paragraph 21 (h). The Director-General shall, in consultation with States Parties, appoint members of the Scientific Advisory Board, who shall serve in their individual capacity. The members of the Board shall be appointed on the basis of their expertise in the particular scientific fields relevant to the implementation of this Convention. The Director-General may also, as appropriate, in consultation with members of the Board, establish temporary working groups of scientific experts to provide recommendations on specific issues. In regard to the above, States Parties may submit lists of experts to the Director-General.

46. In the performance of their duties, the Director-General, the inspectors and the other members of the staff shall not seek or receive instructions from any Government or from any other source external to the Organization. They shall refrain from any action that might reflect on their positions as international officers responsible only to the Conference and the Executive Council.

47. Each State Party shall respect the exclusively international character of the responsibilities of the Director-General, the inspectors and the other members of the staff and not seek to influence them in the discharge of their responsibilities.

E. Privileges and Immunities

48. The Organization shall enjoy on the territory and in any other place under the jurisdiction or control of a State Party such legal capacity and such privileges and immunities as are necessary for the exercise of its functions.

49. Delegates of States Parties, together with their alternates and advisers, representatives appointed to the Executive Council together with their alternates and advisers, the Director-General and the staff of the Organization shall enjoy such privileges and immunities as are necessary in the independent exercise of their functions in connection with the Organization.

50. The legal capacity, privileges, and immunities referred to in this Article shall be defined in agreements between the Organization and the States Parties as well as in an agreement between the Organization and the State in which the headquarters of the Organization is seated. These agreements shall be considered and approved by the Conference pursuant to paragraph 21 (i).

51. Notwithstanding paragraphs 48 and 49, the privileges and immunities enjoyed by the Director-General and the staff of the Technical Secretariat during the conduct of verification activities shall be those set forth in Part II, Section B, of the Verification Annex.

ARTICLE IX

CONSULTATIONS, COOPERATION AND FACT-FINDING

1. States Parties shall consult and cooperate, directly among themselves, or through the Organization or other appropriate international procedures, including procedures within the framework of the United Nations and in accordance with its Charter, on any matter which may be raised relating to the object and purpose, or the implementation of the provisions, of this Convention.

2. Without prejudice to the right of any State Party to request a challenge inspection, States Parties should, whenever possible, first make every effort to clarify and resolve, through exchange of information and consultations among themselves, any matter which may cause doubt about compliance with this Convention, or which gives rise to concerns about a related matter which may be considered ambiguous. A State Party which receives a request from another State Party for clarification of any matter which the requesting State Party believes causes such a doubt or concern shall provide the requesting State Party as soon as possible, but in any case not later than 10 days after the request, with information sufficient to answer the doubt or concern raised along with an explanation of how the information provided resolves the matter. Nothing in this Convention shall affect the right of any two or more States Parties to arrange by mutual consent for inspections or any other procedures among themselves to clarify and resolve any matter which may cause doubt about compliance or gives rise to a concern about a related matter which may be considered ambiguous. Such arrangements shall not affect the rights and obligations of any State Party under other provisions of this Convention.

Procedure for requesting clarification

3. A State Party shall have the right to request the Executive Council to assist in clarifying any situation which may be considered ambiguous or which gives rise to a concern about the possible non-compliance of another State Party with this Convention. The Executive Council shall provide appropriate information in its possession relevant to such a concern.

4. A State Party shall have the right to request the Executive Council to obtain clarification from another State Party on any situation which may be considered ambiguous or which gives rise to a concern about its possible non-compliance with this Convention. In such a case, the following shall apply:

(a) The Executive Council shall forward the request for clarification to the State Party concerned through the Director-General not later than 24 hours after its receipt;
(b) The requested State Party shall provide the clarification to the Executive Council as soon as possible, but in any case not later than 10 days after the receipt of the request;
(c) The Executive Council shall take note of the clarification and forward it to the requesting State Party not later than 24 hours after its receipt;
(d) If the requesting State Party deems the clarification to be inadequate, it shall have the right to request the Executive Council to obtain from the requested State Party further clarification;
(e) For the purpose of obtaining further clarification requested under subparagraph (d), the Executive Council may call on the Director-General to establish a group of experts from the Technical Secretariat, or if appropriate staff are not available in the Technical Secretariat, from elsewhere, to examine all available information and data relevant to the situation causing the concern. The group of experts shall submit a factual report to the Executive Council on its findings;
(f) If the requesting State Party considers the clarification obtained under subparagraphs (d) and (e) to be unsatisfactory, it shall have the right to request a special session of the Executive Council in which States Parties involved that are not members of the Executive Council shall be entitled to take part. In such a special session, the Executive Council shall consider the matter and may recommend any measure it deems appropriate to resolve the situation.

5. A State Party shall also have the right to request the Executive Council to clarify any situation which has been considered ambiguous or has given rise to a concern about its possible non-compliance with this Convention. The Executive Council shall respond by providing such assistance as appropriate.

6. The Executive Council shall inform the States Parties about any request for clarification provided in this Article.

7. If the doubt or concern of a State Party about a possible non-compliance has not been resolved within 60 days after the submission of the request for clarification to the Executive Council, or it believes its doubts warrant urgent consideration, notwithstanding its right to request

a challenge inspection, it may request a special session of the Conference in accordance with Article VIII, paragraph 12 (c). At such a special session, the Conference shall consider the matter and may recommend any measure it deems appropriate to resolve the situation.

Procedures for challenge inspections

8. Each State Party has the right to request an on-site challenge inspection of any facility or location in the territory or in any other place under the jurisdiction or control of any other State Party for the sole purpose of clarifying and resolving any questions concerning possible non-compliance with the provisions of this Convention, and to have this inspection conducted anywhere without delay by an inspection team designated by the Director-General and in accordance with the Verification Annex.

9. Each State Party is under the obligation to keep the inspection request within the scope of this Convention and to provide in the inspection request all appropriate information on the basis of which a concern has arisen regarding possible non-compliance with this Convention as specified in the Verification Annex. Each State Party shall refrain from unfounded inspection requests, care being taken to avoid abuse. The challenge inspection shall be carried out for the sole purpose of determining facts relating to the possible non-compliance.

10. For the purpose of verifying compliance with the provisions of this Convention, each State Party shall permit the Technical Secretariat to conduct the on-site challenge inspection pursuant to paragraph 8.

11. Pursuant to a request for a challenge inspection of a facility or location, and in accordance with the procedures provided for in the Verification Annex, the inspected State Party shall have:

(a) The right and the obligation to make every reasonable effort to demonstrate its compliance with this Convention and, to this end, to enable the inspection team to fulfil its mandate;
(b) The obligation to provide access within the requested site for the sole purpose of establishing facts relevant to the concern regarding possible non-compliance; and
(c) The right to take measures to protect sensitive installations, and to prevent disclosure of confidential information and data, not related to this Convention.

12. With regard to an observer, the following shall apply:

(a) The requesting State Party may, subject to the agreement of the inspected State Party, send a representative who may be a national either of the requesting State Party or of a third State Party, to observe the conduct of the challenge inspection.
(b) The inspected State Party shall then grant access to the observer in accordance with the Verification Annex.
(c) The inspected State Party shall, as a rule, accept the proposed observer, but if the inspected State Party exercises a refusal, that fact shall be recorded in the final report.

13. The requesting State Party shall present an inspection request for an on-site challenge inspection to the Executive Council and at the same time to the Director-General for immediate processing.

14. The Director-General shall immediately ascertain that the inspection request meets the requirements specified in Part X, paragraph 4, of the Verification Annex, and, if necessary, assist the requesting State Party in filing the inspection request accordingly. When the inspection request fulfils the requirements, preparations for the challenge inspection shall begin.

15. The Director-General shall transmit the inspection request to the inspected State Party not less than 12 hours before the planned arrival of the inspection team at the point of entry.

16. After having received the inspection request, the Executive Council shall take cognizance of the Director-General's actions on the request and shall keep the case under its consideration throughout the inspection procedure. However, its deliberations shall not delay the inspection process.

17. The Executive Council may, not later than 12 hours after having received the inspection request, decide by a three-quarter majority of all its members against carrying out the challenge inspection, if it considers the inspection request to be frivolous, abusive or clearly beyond the scope of this Convention as described in paragraph 8. Neither the requesting nor the inspected State Party shall participate in such a decision. If the Executive Council decides against the challenge inspection, preparations shall be stopped, no further action on the inspection request shall be taken, and the States Parties concerned shall be informed accordingly.

18. The Director-General shall issue an inspection mandate for the conduct of the challenge inspection. The inspection mandate shall be the inspection request referred to in paragraphs 8 and 9 put into operational terms, and shall conform with the inspection request.

19. The challenge inspection shall be conducted in accordance with Part X or, in the case of alleged use, in accordance with Part XI of the Verification Annex. The inspection team shall be guided by the principle of conducting the challenge inspection in the least intrusive

manner possible, consistent with the effective and timely accomplishment of its mission.

20. The inspected State Party shall assist the inspection team throughout the challenge inspection and facilitate its task. If the inspected State Party proposes, pursuant to Part X, Section C, of the Verification Annex, arrangements to demonstrate compliance with this Convention, alternative to full and comprehensive access, it shall make every reasonable effort, through consultations with the inspection team, to reach agreement on the modalities for establishing the facts with the aim of demonstrating its compliance.

21. The final report shall contain the factual findings as well as an assessment by the inspection team of the degree and nature of access and cooperation granted for the satisfactory implementation of the challenge inspection. The Director-General shall promptly transmit the final report of the inspection team to the requesting State Party, to the inspected State Party, to the Executive Council and to all other States Parties. The Director-General shall further transmit promptly to the Executive Council the assessments of the requesting and of the inspected States Parties, as well as the views of other States Parties which may be conveyed to the Director-General for that purpose, and then provide them to all States Parties.

22. The Executive Council shall, in accordance with its powers and functions, review the final report of the inspection team as soon as it is presented, and address any concerns as to:

(a) Whether any non-compliance has occurred;
(b) Whether the request had been within the scope of this Convention; and
(c) Whether the right to request a challenge inspection had been abused.

23. If the Executive Council reaches the conclusion, in keeping with its powers and functions, that further action may be necessary with regard to paragraph 22, it shall take the appropriate measures to redress the situation and to ensure compliance with this Convention, including specific recommendations to the Conference. In the case of abuse, the Executive Council shall examine whether the requesting State Party should bear any of the financial implications of the challenge inspection.

24. The requesting State Party and the inspected State Party shall have the right to participate in the review process. The Executive Council shall inform the States Parties and the next session of the Conference of the outcome of the process.

25. If the Executive Council has made specific recommendations to the Conference, the Conference shall consider action in accordance with Article XII.

ARTICLE X

ASSISTANCE AND PROTECTION AGAINST CHEMICAL WEAPONS

1. For the purposes of this Article, "Assistance" means the coordination and delivery to States Parties of protection against chemical weapons, including, inter alia, the following: detection equipment and alarm systems; protective equipment; decontamination equipment and decontaminants; medical antidotes and treatments; and advice on any of these protective measures.

2. Nothing in this Convention shall be interpreted as impeding the right of any State Party to conduct research into, develop, produce, acquire, transfer or use means of protection against chemical weapons, for purposes not prohibited under this Convention.

3. Each State Party undertakes to facilitate, and shall have the right to participate in, the fullest possible exchange of equipment, material and scientific and technological information concerning means of protection against chemical weapons.

4. For the purposes of increasing the transparency of national programmes related to protective purposes, each State Party shall provide annually to the Technical Secretariat information on its programme, in accordance with procedures to be considered and approved by the Conference pursuant to Article VIII, paragraph 21 (i).

5. The Technical Secretariat shall establish, not later than 180 days after entry into force of this Convention and maintain, for the use of any requesting State Party, a data bank containing freely available information concerning various means of protection against chemical weapons as well as such information as may be provided by States Parties.

The Technical Secretariat shall also, within the resources available to it, and at the request of a State Party, provide expert advice and assist the State Party in identifying how its programmes for the development and improvement of a protective capacity against chemical weapons could be implemented.

6. Nothing in this Convention shall be interpreted as impeding the right of States Parties to request and provide assistance bilaterally and to conclude individual agreements with other States Parties concerning the emergency procurement of assistance.

7. Each State Party undertakes to provide assistance through the Organization and to this end to elect to take one or more of the following measures:

(a) To contribute to the voluntary fund for assistance to be established by the Conference at its first session;
(b) To conclude, if possible not later than 180 days after this Convention enters into force for it,

agreements with the Organization concerning the procurement, upon demand, of assistance;
(c) To declare, not later than 180 days after this Convention enters into force for it, the kind of assistance it might provide in response to an appeal by the Organization. If, however, a State Party subsequently is unable to provide the assistance envisaged in its declaration, it is still under the obligation to provide assistance in accordance with this paragraph.

8. Each State Party has the right to request and, subject to the procedures set forth in paragraphs 9, 10 and 11, to receive assistance and protection against the use or threat of use of chemical weapons if it considers that:

(a) Chemical weapons have been used against it;
(b) Riot control agents have been used against it as a method of warfare; or
(c) It is threatened by actions or activities of any State that are prohibited for States Parties by Article I.

9. The request, substantiated by relevant information, shall be submitted to the Director-General, who shall transmit it immediately to the Executive Council and to all States Parties. The Director-General shall immediately forward the request to States Parties which have volunteered, in accordance with paragraphs 7 (b) and (c), to dispatch emergency assistance in case of use of chemical weapons or use of riot control agents as a method of warfare, or humanitarian assistance in case of serious threat of use of chemical weapons or serious threat of use of riot control agents as a method of warfare to the State Party concerned not later than 12 hours after receipt of the request. The Director-General shall initiate, not later than 24 hours after receipt of the request, an investigation in order to provide foundation for further action. He shall complete the investigation within 72 hours and forward a report to the Executive Council. If additional time is required for completion of the investigation, an interim report shall be submitted within the same time-frame. The additional time required for investigation shall not exceed 72 hours. It may, however, be further extended by similar periods. Reports at the end of each additional period shall be submitted to the Executive Council. The investigation shall, as appropriate and in conformity with the request and the information accompanying the request, establish relevant facts related to the request as well as the type and scope of supplementary assistance and protection needed.

10. The Executive Council shall meet not later than 24 hours after receiving an investigation report to consider the situation and shall take a decision by simple majority within the following 24 hours on whether to instruct the Technical Secretariat to provide supplementary assistance. The Technical Secretariat shall immediately transmit to all States Parties and relevant international organizations the investigation report and the decision taken by the Executive Council. When so decided by the Executive Council, the Director-General shall provide assistance immediately. For this purpose, the Director-General may cooperate with the requesting State Party, other States Parties and relevant international organizations. The States Parties shall make the fullest possible efforts to provide assistance.

11. If the information available from the ongoing investigation or other reliable sources would give sufficient proof that there are victims of use of chemical weapons and immediate action is indispensable, the Director-General shall notify all States Parties and shall take emergency measures of assistance, using the resources the Conference has placed at his disposal for such contingencies. The Director-General shall keep the Executive Council informed of actions undertaken pursuant to this paragraph.

ARTICLE XI

ECONOMIC AND TECHNOLOGICAL DEVELOPMENT

1. The provisions of this Convention shall be implemented in a manner which avoids hampering the economic or technological development of States Parties, and international cooperation in the field of chemical activities for purposes not prohibited under this Convention including the international exchange of scientific and technical information and chemicals and equipment for the production, processing or use of chemicals for purposes not prohibited under this Convention.

2. Subject to the provisions of this Convention and without prejudice to the principles and applicable rules of international law, the States Parties shall:

(a) Have the right, individually or collectively, to conduct research with, to develop, produce, acquire, retain, transfer, and use chemicals;
(b) Undertake to facilitate, and have the right to participate in, the fullest possible exchange of chemicals, equipment and scientific and technical information relating to the development and application of chemistry for purposes not prohibited under this Convention;
(c) Not maintain among themselves any restrictions, including those in any international agreements, incompatible with the obligations undertaken under this Convention, which would restrict or impede

trade and the development and promotion of scientific and technological knowledge in the field of chemistry for industrial, agricultural, research, medical, pharmaceutical or other peaceful purposes;
(d) Not use this Convention as grounds for applying any measures other than those provided for, or permitted, under this Convention nor use any other international agreement for pursuing an objective inconsistent with this Convention;
(e) Undertake to review their existing national regulations in the field of trade in chemicals in order to render them consistent with the object and purpose of this Convention.

ARTICLE XII

MEASURES TO REDRESS A SITUATION AND TO ENSURE COMPLIANCE, INCLUDING SANCTIONS

1. The Conference shall take the necessary measures, as set forth in paragraphs 2, 3 and 4, to ensure compliance with this Convention and to redress and remedy any situation which contravenes the provisions of this Convention. In considering action pursuant to this paragraph, the Conference shall take into account all information and recommendations on the issues submitted by the Executive Council.

2. In cases where a State Party has been requested by the Executive Council to take measures to redress a situation raising problems with regard to its compliance, and where the State Party fails to fulfil the request within the specified time, the Conference may, inter alia, upon the recommendation of the Executive Council, restrict or suspend the State Party's rights and privileges under this Convention until it undertakes the necessary action to conform with its obligations under this Convention.

3. In cases where serious damage to the object and purpose of this Convention may result from activities prohibited under this Convention, in particular by Article I, the Conference may recommend collective measures to States Parties in conformity with international law.

4. The Conference shall, in cases of particular gravity, bring the issue, including relevant information and conclusions, to the attention of the United Nations General Assembly and the United Nations Security Council.

ARTICLE XIII

RELATIONS TO OTHER INTERNATIONAL AGREEMENTS

Nothing in this Convention shall be interpreted as in any way limiting or detracting from the obligations assumed by any State under the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on 17 June 1925, and under the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction, signed at London, Moscow and Washington on 10 April 1972.

ARTICLE XIV

SETTLEMENT OF DISPUTES

1. Disputes that may arise concerning the application or the interpretation of this Convention shall be settled in accordance with the relevant provisions of this Convention and in conformity with the provisions of the Charter of the United Nations.

2. When a dispute arises between two or more States Parties, or between one or more States Parties and the Organization, relating to the interpretation or application of this Convention, the parties concerned shall consult together with a view to the expeditious settlement of the dispute by negotiation or by other peaceful means of the parties' choice, including recourse to appropriate organs of this Convention and, by mutual consent, referral to the International Court of Justice in conformity with the Statute of the Court. The States Parties involved shall keep the Executive Council informed of actions being taken.

3. The Executive Council may contribute to the settlement of a dispute by whatever means it deems appropriate, including offering its good offices, calling upon the States Parties to a dispute to start the settlement process of their choice and recommending a time-limit for any agreed procedure.

4. The Conference shall consider questions related to disputes raised by States Parties or brought to its attention by the Executive Council. The Conference shall, as it finds necessary, establish or entrust organs with tasks related to the settlement of these disputes in conformity with Article VIII, paragraph 21 (f).

5. The Conference and the Executive Council are separately empowered, subject to authorization from the General Assembly of the United Nations, to request the International Court of Justice to give an advisory opinion on any legal question arising within the scope of the activities of the Organization. An agreement between the Organization and the United Nations shall be concluded for this purpose in accordance with Article VIII, paragraph 34 (a).

6. This Article is without prejudice to Article IX or to the provisions on measures to redress a situation and to ensure compliance, including sanctions.

ARTICLE XV

AMENDMENTS

1. Any State Party may propose amendments to this Convention. Any State Party may also propose changes, as specified in paragraph 4, to the Annexes of this Convention. Proposals for amendments shall be subject to the procedures in paragraphs 2 and 3. Proposals for changes, as specified in paragraph 4, shall be subject to the procedures in paragraph 5.

2. The text of a proposed amendment shall be submitted to the Director-General for circulation to all States Parties and to the Depositary. The proposed amendment shall be considered only by an Amendment Conference. Such an Amendment Conference shall be convened if one third or more of the States Parties notify the Director-General not later than 30 days after its circulation that they support further consideration of the proposal. The Amendment Conference shall be held immediately following a regular session of the Conference unless the requesting States Parties ask for an earlier meeting. In no case shall an Amendment Conference be held less than 60 days after the circulation of the proposed amendment.

3. Amendments shall enter into force for all States Parties 30 days after deposit of the instruments of ratification or acceptance by all the States Parties referred to under subparagraph (b) below:

(a) When adopted by the Amendment Conference by a positive vote of a majority of all States Parties with no State Party casting a negative vote; and
(b) Ratified or accepted by all those States Parties casting a positive vote at the Amendment Conference.

4. In order to ensure the viability and the effectiveness of this Convention, provisions in the Annexes shall be subject to changes in accordance with paragraph 5, if proposed changes are related only to matters of an administrative or technical nature. All changes to the Annex on Chemicals shall be made in accordance with paragraph 5. Sections A and C of the Confidentiality Annex, Part X of the Verification Annex, and those definitions in Part I of the Verification Annex which relate exclusively to challenge inspections, shall not be subject to changes in accordance with paragraph 5.

5. Proposed changes referred to in paragraph 4 shall be made in accordance with the following procedures:

(a) The text of the proposed changes shall be transmitted together with the necessary information to the Director-General. Additional information for the evaluation of the proposal may be provided by any State Party and the Director-General. The Director-General shall promptly communicate any such proposals and information to all States Parties, the Executive Council and the Depositary;
(b) Not later than 60 days after its receipt, the Director-General shall evaluate the proposal to determine all its possible consequences for the provisions of this Convention and its implementation and shall communicate any such information to all States Parties and the Executive Council;
(c) The Executive Council shall examine the proposal in the light of all information available to it, including whether the proposal fulfils the requirements of paragraph 4. Not later than 90 days after its receipt, the Executive Council shall notify its recommendation, with appropriate explanations, to all States Parties for consideration. States Parties shall acknowledge receipt within 10 days;
(d) If the Executive Council recommends to all States Parties that the proposal be adopted, it shall be considered approved if no State Party objects to it within 90 days after receipt of the recommendation. If the Executive Council recommends that the proposal be rejected, it shall be considered rejected if no State Party objects to the rejection within 90 days after receipt of the recommendation;
(e) If a recommendation of the Executive Council does not meet with the acceptance required under subparagraph (d), a decision on the proposal, including whether it fulfils the requirements of paragraph 4, shall be taken as a matter of substance by the Conference at its next session;
(f) The Director-General shall notify all States Parties and the Depositary of any decision under this paragraph;
(g) Changes approved under this procedure shall enter into force for all States Parties 180 days after the date of notification by the Director-General of their approval unless another time period is recommended by the Executive Council or decided by the Conference.

ARTICLE XVI

DURATION AND WITHDRAWAL

1. This Convention shall be of unlimited duration.

2. Each State Party shall, in exercising its national sovereignty, have the right to withdraw from this Convention if it decides that extraordinary events, related to the subject-matter of this Convention, have jeopardized the supreme interests of its country. It shall give notice of such withdrawal 90 days in advance to all other States

Parties, the Executive Council, the Depositary and the United Nations Security Council. Such notice shall include a statement of the extraordinary events it regards as having jeopardized its supreme interests.

3. The withdrawal of a State Party from this Convention shall not in any way affect the duty of States to continue fulfilling the obligations assumed under any relevant rules of international law, particularly the Geneva Protocol of 1925.

ARTICLE XVII

STATUS OF THE ANNEXES

The Annexes form an integral part of this Convention. Any reference to this Convention includes the Annexes.

ARTICLE XVIII

SIGNATURE

This Convention shall be open for signature for all States before its entry into force.

ARTICLE XIX

RATIFICATION

This Convention shall be subject to ratification by States Signatories according to their respective constitutional processes.

ARTICLE XX

ACCESSION

Any State which does not sign this Convention before its entry into force may accede to it at any time thereafter.

ARTICLE XXI

ENTRY INTO FORCE

1. This Convention shall enter into force 180 days after the date of the deposit of the 65th instrument of ratification, but in no case earlier than two years after its opening for signature.

2. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Convention, it shall enter into force on the 30th day following the date of deposit of their instrument of ratification or accession.

ARTICLE XXII

RESERVATIONS

The Articles of this Convention shall not be subject to reservations. The Annexes of this Convention shall not be subject to reservations incompatible with its object and purpose.

ARTICLE XXIII

DEPOSITARY

The Secretary-General of the United Nations is hereby designated as the Depositary of this Convention and shall, inter alia:

(a) Promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification or accession and the date of the entry into force of this Convention, and of the receipt of other notices;
(b) Transmit duly certified copies of this Convention to the Governments of all signatory and acceding States; and
(c) Register this Convention pursuant to Article 102 of the Charter of the United Nations.

ARTICLE XXIV

AUTHENTIC TEXTS

This Convention, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United Nations.

IN WITNESS WHEREOF the undersigned, being duly authorized to that effect, have signed this Convention.

Done at Paris on the thirteenth day of January, one thousand nine hundred and ninety-three.

ANNEX ON CHEMICALS

GUIDELINES FOR SCHEDULES OF CHEMICALS[1]

Guidelines for Schedule 1

1. The following criteria shall be taken into account in considering whether a toxic chemical or precursor should be included in Schedule 1:

(a) It has been developed, produced, stockpiled or used as a chemical weapon as defined in Article II;

(b) It poses otherwise a high risk to the object and purpose of this Convention by virtue of its high potential for use in activities prohibited under this Convention because one or more of the following conditions are met:

(i) It possesses a chemical structure closely related to that of other toxic chemicals listed in Schedule 1, and has, or can be expected to have, comparable properties;
(ii) It possesses such lethal or incapacitating toxicity as well as other properties that would enable it to be used as a chemical weapon;
(iii) It may be used as a precursor in the final single technological stage of production of a toxic chemical listed in Schedule 1, regardless of whether this stage takes place in facilities, in munitions or elsewhere;

(c) It has little or no use for purposes not prohibited under this Convention.

Guidelines for Schedule 2
1. The following criteria shall be taken into account in considering whether a toxic chemical not listed in Schedule 1 or a precursor to a Schedule 1 chemical or to a chemical listed in Schedule 2, part A, should be included in Schedule 2:

(a) It poses a significant risk to the object and purpose of this Convention because it possesses such lethal or incapacitating toxicity as well as other properties that could enable it to be used as a chemical weapon;
(b) It may be used as a precursor in one of the chemical reactions at the final stage of formation of a chemical listed in Schedule 1 or Schedule 2, part A;
(c) It poses a significant risk to the object and purpose of this Convention by virtue of its importance in the production of a chemical listed in Schedule 1 or Schedule 2, part A;
(d) It is not produced in large commercial quantities for purposes not prohibited under this Convention.

Guidelines for Schedule 3
3. The following criteria shall be taken into account in considering whether a toxic chemical or precursor, not listed in other Schedules, should be included in Schedule 3:

(a) It has been produced, stockpiled or used as a chemical weapon;
(b) It poses otherwise a risk to the object and purpose of this Convention because it possesses such lethal or incapacitating toxicity as well as other properties that might enable it to be used as a chemical weapon;
(c) It poses a risk to the object and purpose of this Convention by virtue of its importance in the production of one or more chemicals listed in Schedule 1 or Schedule 2, part B;
(d) It may be produced in large commercial quantities for purposes not prohibited under this Convention.

B. SCHEDULES OF CHEMICALS

The following Schedules list toxic chemicals and their precursors. For the purpose of implementing this Convention, these Schedules identify chemicals for the application of verification measures according to the provisions of the Verification Annex. Pursuant to Article II, subparagraph 1 (a), these Schedules do not constitute a definition of chemical weapons.

(Whenever reference is made to groups of dialkylated chemicals, followed by a list of alkyl groups in parentheses, all chemicals possible by all possible combinations of alkyl groups listed in the parentheses are considered as listed in the respective Schedule as long as they are not explicitly exempted. A chemical marked "*" on Schedule 2, part A, is subject to special thresholds for declaration and verification, as specified in Part VII of the Verification Annex.)

Schedule 1
(CAS registry number)

A. Toxic chemicals:
(1) O-Alkyl (<C10, incl. cycloalkyl) alkyl (Me, Et, n- Pr or i-Pr)-phosphonofluoridates, e.g.: Sarin: O- Isopropyl methylphosphonofluoridate (107-44-8); Soman: O-Pinacolyl methylphosphonofluoridate (96-64-0)

(2) O-Alkyl (<C10, incl. cycloalkyl) N,N-dialkyl (Me, Et, n- Pr or i- Pr) phosphoramidocyanidates

e.g. Tabun: O-Ethyl N,N-dimethyl phosphoramidocyanidate (77-81-6)

(3) O-Alkyl (H or <C10, incl. cycloalkyl) S-2-dialkyl (Me, Et, n- Pr or i- Pr)-aminoethyl alkyl (Me, Et, n- Pr or i- Pr) phosphonothiolates and corresponding alkylated or protonated salts, e.g. VX: O-Ethyl S-2-diisopropylaminoethyl methyl phosphonothiolate (50782- 69- 9)

(4) Sulfur mustards:

2-Chloroethylchloromethylsulfide (2625-76-5)
Mustard gas: Bis(2-chloroethyl)sulfide (505-60-2)
Bis(2-chloroethylthio)methane (63869-13-6)
Sesquimustard: 1,2-Bis(2-chloroethylthio)ethane (3563-36-8)

1,3- Bis(2-chloroethylthio)-n-propane (63905-10-2)
1,4- Bis(2-chloroethylthio)-n-butane (142868-93-7)
1,5- Bis(2-chloroethylthio)-n-pentane (142868-94-8)
Bis(2-chloroethylthiomethyl)ether (63918-90-1)
O-Mustard: Bis(2- chloroethylthioethyl)ether (63918-89-8)

(5) Lewisites:

Lewisite 1: 2-Chlorovinyldichloroarsine (541-25-3)
Lewisite 2: Bis(2-chlorovinyl)chloroarsine (40334-69-8)
Lewisite 3: Tris(2-chlorovinyl)arsine (40334-70-1)

(6) Nitrogen mustards:

HN-1: Bis(2-chloroethyl)ethylamine (538-07-8)
HN-2: Bis(2-chloroethyl)methylamine (51-75-2)
HN-3: Tris(2-chloroethyl)amine (555-77-1)

(7) Saxitoxin (35523-89-8) [note: also a biotoxin]
(8) Ricin (9009-86-3) [note: also a biotoxin]

B. Precursors:
(9) Alkyl (Me, Et, n- Pr or i- Pr) phosphonyldifluorides, e.g. DF: Methylphosphonyldifluoride (676-99-3)

(10) O-Alkyl (H or <C10, incl. cycloalkyl) O-2-dialkyl (Me, Et, n-Pr or i-Pr)-aminoethyl alkyl (Me, Et, n- Pr or i-Pr) phosphonites and corresponding alkylated or protonated salts, e.g. QL: O-Ethyl O-2 diisopropylaminoethyl methylphosphonite (57856-11-8)

(11) Chlorosarin: O-Isopropyl methylphosphonochloridate (1445-76-7)

(12) Chlorosoman: O-Pinacolyl methylphosphonochloridate (7040-57-5)

Schedule 2
A. Toxic chemicals:
(1) Amiton: O,O-Diethyl S-[2-(diethylamino)ethyl] phosphorothiolate (78-53-5) and corresponding alkylated or protonated salts

(2) PFIB: 1,1,3,3,3-Pentafluoro-2-(trifluoromethyl)-1-propene (382-21-8)

(3) BZ: 3-Quinuclidinyl benzilate (*) (6581-06-2)

B. Precursors:
(4) Chemicals, except for those listed in Schedule 1, containing a phosphorus atom to which is bonded one methyl, ethyl or propyl (normal or iso) group but not further carbon atoms, e.g. Methylphosphonyl dichloride (676-97-1), Dimethyl methylphosphonate (756-79-6)

[Exemption: Fonofos: O-Ethyl S-phenyl ethylphosphonothiolothionate (944-22-9)]

(5) N,N- Dialkyl (Me, Et, n-Pr or i-Pr) phosphoramidic dihalides

(6) Dialkyl (Me, Et, n- Pr or i-Pr) N,N-dialkyl (Me, Et, n- Pr or i-Pr)- phosphoramidates

(7) Arsenic trichloride (7784-34-1)

(8) 2,2- Diphenyl-2-hydroxyacetic acid (76-93-7)

(9) Quinuclidin-3-ol (1619-34-7)

(10) N,N- Dialkyl (Me, Et, n- Pr or i-Pr) aminoethyl-2-chlorides and corresponding protonated salts

(11) N,N- Dialkyl (Me, Et, n- Pr or i-Pr) aminoethane-2-ols and corresponding protonated salts

[Exemptions: N,N- Dimethylaminoethanol (108-01-0) and corresponding protonated salts, N,N- Diethylaminoethanol (100-37-8) and corresponding protonated salts

(12) N,N-Dialkyl (Me, Et, n- Pr or i-Pr) aminoethane-2-thiols and corresponding protonated salts

(13) Thiodiglycol: Bis(2-hydroxyethyl)sulfide (111-48-8)

(14) Pinacolyl alcohol: 3,3-Dimethylbutan-2-ol (464-07- 3)

Schedule 3
A. Toxic chemicals:
(1) Phosgene: Carbonyl dichloride (75-44-5)
(2) Cyanogen chloride (506-77-4)
(3) Hydrogen cyanide (74-90-8)
(4) Chloropicrin: Trichloronitromethane (76-06-2)

B. Precursors:
(5) Phosphorus oxychloride (10025-87-3)
(6) Phosphorus trichloride (7719-12-2)
(7) Phosphorus pentachloride (10026-13-8)
(8) Trimethyl phosphite (121-45-9)
(9) Triethyl phosphite (122-52-1)
(10) Dimethyl phosphite (868-85-9)
(11) Diethyl phosphite (762-04-9)
(12) Sulfur monochloride (10025-67-9)
(13) Sulfur dichloride (10545-99-0)
(14) Thionyl chloride (7719-09-7)
(15) Ethyldiethanolamine (139-87-7)
(16) Methyldiethanolamine (105-59-9)
(17) Triethanolamine (102-71-6)

STATES PARTIES TO THE CHEMICAL WEAPONS CONVENTION (CWC)[1]

(As of 5 February 2004)

1. Afghanistan
2. Albania

3. Algeria
4. Andorra
5. Argentina
6. Armenia
7. Australia
8. Austria
9. Azerbaijan
10. Bahrain
11. Bangladesh
12. Belarus
13. Belgium
14. Belize
15. Benin
16. Bolivia
17. Bosnia and Herzegovina
18. Botswana
19. Brazil
20. Brunei Darussalam
21. Bulgaria
22. Burkina Faso
23. Burundi
24. Cameroon
25. Canada
26. Cape Verde
27. Chile
28. China
29. Colombia
30. Cook Islands
31. Costa Rica
32. Cote d'Ivoire
33. Croatia
34. Cuba
35. Cyprus
36. Czech Republic
37. Denmark
38. Dominica
39. Ecuador
40. El Salvador
41. Equatorial Guinea
42. Eritrea
43. Estonia
44. Ethiopia
45. Fiji
46. Finland
47. France
48. Gabon
49. Gambia
50. Georgia
51. Germany
52. Ghana
53. Greece
54. Guatemala
55. Guinea
56. Guyana
57. Holy See
58. Hungary
59. Iceland
60. India
61. Indonesia
62. Iran (Islamic Republic of)
63. Ireland
64. Italy
65. Jamaica
66. Japan
67. Jordan
68. Kazakhstan
69. Kenya
70. Kiribati
71. Kuwait
72. Kyrgyzstan
73. Lao People's Democratic Republic
74. Latvia
75. Lesotho
76. Libyan Arab Jamahiriya
77. Liechtenstein
78. Libya (Libyian Arab Jamahiriya)
79. Lithuania
80. Luxembourg
81. Malawi
82. Malaysia
83. Maldives
84. Mali
85. Malta
86. Mauritania
87. Mauritius
88. Mexico
89. Micronesia (Federated States of)
90. Monaco
91. Mongolia
92. Morocco
93. Mozambique
94. Namibia
95. Nauru
96. Nepal
97. Netherlands
98. New Zealand
99. Nicaragua
100. Niger
101. Nigeria
102. Norway
103. Oman
104. Pakistan
105. Palau
106. Panama
107. Papua New Guinea
108. Paraguay
109. Peru
110. Philippines

111. Poland
112. Portugal
113. Qatar
114. Republic of Korea
115. Republic of Moldova
116. Romania
117. Russian Federation
118. Saint Lucia
119. Saint Vincent and the Grenadines
120. Samoa
121. San Marino
122. Sao Tome and Principe
123. Saudi Arabia
124. Senegal
125. Serbia and Montenegro
126. Seychelles
127. Singapore
128. Slovakia
129. Slovenia
130. South Africa
131. Spain
132. Sri Lanka
133. Sudan
134. Suriname
135. Swaziland
136. Sweden
137. Switzerland
138. Tajikistan
139. Thailand
140. The Former Yugoslav Republic of Macedonia
141. Timor Leste
142. Togo
143. Tonga
144. Trinidad and Tobago
145. Tunisia
146. Turkey
147. Turkmenistan
148. Tuvalu
149. Uganda
150. Ukraine
151. United Arab Emirates
152. United Kingdom of Great Britain and Northern Ireland
153. United Republic of Tanzania
154. United States of America
155. Uruguay
156. Uzbekistan
157. Venezuela
158. Viet Nam
159. Yemen
160. Zambia
161. Zimbabwe

Notes

1. http://www.opcw.nl

Australia Group

Annex 7
Australia Group Doc
AG/Dec92/BW/Chair/8

LIST OF DUAL-USE BIOLOGICAL EQUIPMENT FOR EXPORT CONTROL

(FINAL VERSION)

The experts propose that the following items of equipment should be subject to export controls.

1. Complete containment facilities at P3, P4 contrainment level

Complete containment facilities that meet the criteria for P3 or P4 (BL3, BL4, L3, L4) containment as specified in the WHO Laboratory Biosafety manual (Geneva, 1983) should be subject to export control.

2. Fermenters*

Fermenters capable of cultivation of pathogenic micro-organisms, viruses or for toxin production, without the propagation of aerosols, and having all the following characteristics:

(a) capacity equal to or greater than 300 litres;
(b) double or multiple sealing joints within the steam containment area;
(c) capable of in-situ sterilisation in a closed state.

* Sub-groups of fermenters include bioreactors, chemostats and continuous-flow systems.

3. Centrifugal Separators*

Centrifugal separators capable of the continuous separation of pathogenic micro-organisms, without the propagation of aerosols, and having all the following characteristics:

(a) flow rate greater than 100 litres per hour;
(b) components of polished stainless steel or titanium;
(c) double or muliple sealing joints within the steam containment area;
(d) capable of in-situ steam sterilisation in a closed state.

* Centrifugal separators include decanters.

4. Cross-flow Filtration Equipment

Cross-flow filtration equipment designed for continuous separation of pathogenic microorganisms, viruses, toxins and cell cultures without the propagation of aerosols, having all the following characteristics:

(a) equal to or greater than 5 square metres;
(b) capable of in-situ sterilisation.

5. Freeze-drying Equipment

Steam sterilisable freeze-drying equipment with a condensor capacity greater than 50 kgs of ice in 24 hours and less than 1000 kgs of ice in 24 hours.

6. Equipment that incorporates or is contained in P3 or P4 (BL3, BL4, L3, L4) containment housing, as follows:

(a) Independently ventilated protective full or half suits;
(b) Class III biological safety cabinets or isolators with similar performance standards.

7. Aerosol inhalation chambers

Chambers designed for aerosol challenge testing with pathogenic microorganisms, viruses or toxins and having a capacity of 1 cubic metre or greater.

The experts propose that the following item be included in awareness raising guidelines to industry:

1. Equipment for the micro-encapsulation of live micro-organisms and toxins in the range of 1-10 um particle size, specifically:

(a) Interfacial polycondensors;
(b) Phase separators.

2. Fermenters of less than 300 litre capacity with special emphasis on aggregate orders or designs for use in combined systems.
3. Conventional or turbulent air-flow clean-air rooms and self-contained fan-HEPA filter units that may be used for P3 or P4 (BL3, BL4, L3, L4) containment facilities.

AUSTRALIA GROUP LISTS:[1]

AUSTRALIA GROUP CONTROL LIST OF DUAL-USE CHEMICALS

1. Thiodiglycol
2. Phosphorus oxychloride
3. Dimethyl methylphosphonate
4. Methyl phosphonyl difluoride
5. Methyl phosphonyl dichloride
6. Dimethyl phosphite
7. Phosphorus trichloride
8. Trimethyl phosphite
9. Thionyl chloride
10. 3-Hydroxy-l-methylpiperidine
11. N,N-Diisopropyl-(beta) aminoethyl chloride
12. N,N-Diisopropyl-(beta)-aminoethane thiol
13. 3-Quinuclidinol
14. Potassium fluoride
15. 2-Chloroethanol
16. Dimethylamine
17. Diethyl ethylphosphonate
18. Diethyl N,N-dimethylosphoramidate
19. Diethyl phosphite
20. Dimethylamine hydrochloride
21. Ethyl phosphinyl dichloride
22. Ethyl phosphonyl dichloride
23. Ethyl Phosphonyl difluoride
24. Hydrogen fluoride
25. Methyl benzilate
26. Methyl phosphinyl dichloride
27. N,N-Diisopropyl-(beta)-amino-ethanol
28. Pinacolyl alcohol
29. O-Ethyl 2-diisopropylamino-ethyl methylphosphonite
30. Triethyl phosphite
31. Arsenic yrichloride
32. Benzilic acid
33. Diethyl methylphosphonite
34. Dimethyl ethylphosphonate
35. Ethyl phosphinyl difluoride
36. Methyl phosphinyl difluoride
37. 3 -Quinuclidone
38. Phosphorus pentachloride
39. Pinacolone
40. Potassium cyanide
41. Potassium bifluoride
42. Ammonium bifluoride
43. Sodium bifluoride
44. Sodium fluoride
45. Sodium cyanide
46. Tri-ethanolamine
47. Phosphorus pentasulphide
48. Di-isopropylamine
49. Diethylaminoethanol
50. Sodium sulphide
51. Sulphur monochloride
52. Sulphur dichloride
53. Triethanolamine hydrochloride
54. N,N-Diisopropyl-2-Aminoethyl Chloride Hydrochloride

Notes:

1. http://www.australiagroup.net/en/control_list/bio_agents.htm

LIST OF BIOLOGICAL AGENTS FOR EXPORT CONTROL CORE LIST 1 (AUGUST 2003)

Viruses

V1. Chikungunya virus

V2. Congo-Crimean haemorrhagic fever virus
V3. Dengue fever virus
V4. Eastern equine encephalitis virus
V5. Ebola virus
V6. Hantaan virus
V7. Junin virus
V8. Lassa fever virus
V9. Lymphocytic choriomeningitis virus
V10. Machupo virus
V11. Marburg virus
V12. Monkey pox virus
V13. Rift Valley fever virus
V14. Tick-borne encephalitis virus (Russian Spring-Summer encephalitis virus)
V15. Variola virus
V16. Venezuelan equine encephalitis virus
V17. Western equine encephalitis virus
V18. White pox
V19. Yellow fever virus
V20. Japanese encephalitis virus
V21. Kyasanur Forest virus
V22. Louping ill virus
V23. Murray Valley encephalitis virus
V24. Omsk haemorrhagic fever virus
V25. Oropouche virus
V26. Powassan virus
V27. Rocio virus
V28. St Louis encephalitis virus
V29. Hendra virus (Equine morbillivirus)
V30. South American haemorrhagic fever (Sabia, Flexal, Guanarito)
V31. Pulmonary & renal syndrome-haemorrhagic fever viruses (Seoul, Dobrava, Puumala, Sin Nombre)
V32. Nipah virus

Rickettsiae

R1. *Coxiella burnetii*
R2. *Bartonella quintana* (*Rochalimea quintana, Rickettsia quintana*)
R3. *Rickettsia prowazeki*
R4. *Rickettsia rickettsii*

Bacteria

B1. *Bacillus anthracis*
B2. *Brucella abortus*
B3. *Brucella melitensis*
B4. *Brucella suis*
B5. *Chlamydia psittaci*
B6. *Clostridium botulinum*
B7. *Francisella tularensis*
B8. *Burkholderia mallei* (*Pseudomonas mallei*)
B9. *Burkholderia pseudomallei* (*Pseudomonas pseudomallei*)
B10. *Salmonella typhi*
B11. *Shigella dysenteriae*
B12. *Vibrio cholerae*
B13. *Yersinia pestis*
B14. *Clostridium perfringens,* epsilon toxin producing types2
B15. Enterohaemorrhagic *Escherichia coli,* serotype O157 and other verotoxin producing serotypes

Toxins

T1. Botulinum toxins4
T2. Clostridium perfringens toxins
T3. Conotoxin
T4. Ricin
T5. Saxitoxin
T6. Shiga toxin
T7. Staphylococcus aureus toxins
T8. Tetrodotoxin
T9. Verotoxin
T10. Microcystin (Cyanginosin)
T11. Aflatoxins
T12. Abrin
T13. Cholera toxin
T14. Diacetoxyscirpenol toxin
T15. T-2 toxin
T16. HT-2 toxin
T17. Modeccin toxin
T18. Volkensin toxin
T19. Viscum Album Lectin 1 (Viscumin)

1. Biological agents are controlled when they are an isolated live culture of a pathogen agent, or a preparation of a toxin agent which has been isolated or extracted from any source, or material including living material which has been deliberately inoculated or contaminated with the agent. Isolated live cultures of a pathogen agent include live cultures in dormant form or in dried preparations, whether the agent is natural, enhanced or modified.

An agent is covered by this list except when it is in the form of a vaccine. A vaccine is a medicinal product in a pharmaceutical formulation licensed by, or having marketing or clinical trial authorisation from, the regulatory authorities of either the country of manufacture or of use, which is intended to stimulate a protective immunological response in humans or animals in order to prevent disease in those to whom or to which it is administered.

2. It is understood that limiting this control to epsilon toxin-producing strains of *Clostridium perfringens* therefore exempts from control the transfer of other *Clostridium perfringens* strains to be used as positive control cultures for food testing and quality control.

3. Excluding immunotoxins.

4. Excluding botulinum toxins in product form meeting all of the following criteria: are pharmaceutical for-

mulations designed for human administration in the treatment of medical conditions; are pre-packaged for distribution as medical products;

are authorised by a state authority to be marketed as medical products.

Genetic Elements and Genetically-modified Organisms:

G1. Genetic elements that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in the list.

G2. Genetic elements that contain nucleic acid sequences coding for any of the toxins in the list, or for their sub-units.

G3. Genetically-modified organisms that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in the list.

G4. Genetically-modified organisms that contain nucleic acid sequences coding for any of the toxins in the list or for their sub-units.

Technical note:

Genetic elements include inter alia chromosomes, genomes, plasmids, transposons, and vectors whether genetically modified or unmodified. These controls do not apply to nucleic acid sequences associated with the pathogenicity of enterohaemorrhagic *Escherichia coli*, serotype O157 and other verotoxin producing strains, other than those coding for the verotoxin, or for its sub-units.

WARNING LIST1

Bacteria

WB1. *Clostridium tetani**

WB2. *Legionella pneumophila*

WB3. *Yersinia pseudotuberculosis*

* Australia Group recognises that this organism is ubiquitous, but, as it has been acquired in the past as part of biological warfare programs, it is worthy of special caution.

1. Biological agents are controlled when they are an isolated live culture of a pathogen agent, or a preparation of a toxin agent which has been isolated or extracted from any source, or material including living material which has been deliberately inoculated or contaminated with the agent. Isolated live cultures of a pathogen agent include live cultures in dormant form or in dried preparations, whether the agent is natural, enhanced or modified.

An agent is covered by this list except when it is in the form of a vaccine. A vaccine is a medicinal product in a pharmaceutical formulation licensed by, or having marketing or clinical trial authorisation from, the regulatory authorities of either the country of manufacture or of use, which is intended to stimulate a protective immunological response in humans or animals in order to prevent disease in those to whom or to which it is administered.

Genetic Elements and Genetically-modified Organisms:

WG1. Genetic elements that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in the list.

WG2. Genetic elements that contain nucleic acid sequences coding for any of the toxins in the list, or for their sub-units.

WG3. Genetically-modified organisms that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in the list.

WG4. Genetically-modified organisms that contain nucleic acid sequences coding for any of the toxins in the list or for their sub-units.

Technical note:

Genetic elements include inter alia chromosomes, genomes, plasmids, transposons, and vectors whether genetically modified or unmodified.

AUSTRALIA GROUP: LIST OF ANIMAL PATHOGENS FOR EXPORT CONTROL[2]

CORE LIST1

Viruses

AV1. African swine fever virus
AV2. Avian influenza virus2
AV3. Bluetongue virus
AV4. Foot and mouth disease virus
AV5. Goat pox virus
AV6. Herpes virus (Aujeszky's disease)
AV7. Hog cholera virus (synonym: swine fever virus)
AV8. Lyssa virus
AV9. Newcastle disease virus
AV10. Peste des petits ruminants virus
AV11. Porcine enterovirus type 9 (synonym: swine vesicular disease virus)
AV12. Rinderpest virus
AV13. Sheep pox virus
AV14. Teschen disease virus
AV15. Vesicular stomatitis virus
AV16. Lumpy skin disease virus
AV17. African horse sickness virus

1. Except where the agent is in the form of a vaccine.

2. This includes only those Avian influenza viruses of high pathogenicity as defined in EC Directive 92/40/EC:

"Type A viruses with an IVPI (intravenous pathogenicity index) in 6 week old chickens of greater than 1.2: or Type A viruses H5 or H7 subtype for which nucleotide sequencing has demonstrated multiple basic amino acids at the cleavage site of haemagglutinin"

Bacteria
AB3. *Mycoplasma mycoides*

Genetic Elements and Genetically-modified Organisms
AG1 Genetic elements that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in the list.

AG2 Genetically-modified organisms that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in the list.

Technical note: Genetic elements include inter alia chromosomes, genomes, plasmids, transposons, and vectors whether genetically modified or unmodified.

AUSTRALIA GROUP: LIST OF PLANT PATHOGENS FOR EXPORT CONTROLS3

Bacteria
PB1. *Xanthomonas albilineans*
PB2. *Xanthomonas campestris* pv. *citri*

Fungi
PF1. *Colletotrichum coffeanum* var. *virulans* (*Colletotrichum kahawae*)
PF2. *Cochliobolus miyabeanus* (*Helminthosporium oryzae*)
PF3. *Microcyclus ulei* (syn. *Dothidella ulei*)
PF4. *Puccinia graminis* (syn. *Puccinia graminis* f. sp. *tritici*)
PF5. *Puccinia striiformis* (syn. *Puccinia glumarum*)
PF6. *Pyricularia grisea* / *Pyricularia oryzae*

Genetic Elements and Genetically-modified Organisms:
PG1 Genetic elements that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in the Core List.

PG2 Genetically-modified organisms that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in the Core List.

Technical note: Genetic elements include *inter alia* chromosomes, genomes, plasmids, transposons, and vectors whether genetically modified or unmodified.

ITEMS FOR INCLUSION IN AWARENESS-RAISING GUIDELINES

Bacteria
PWB1. *Xanthomonas campestris* pv. *Oryzae*
PWB2. *Xylella fastidiosa*

Fungi
PWF1. *Deuterophoma tracheiphila* (syn. *Phoma tracheiphila*)
PWF2. *Monilia rorei* (syn. *Moniliophthora rorei*)

Viruses
PWV1 Banana bunchy top virus

Genetic Elements and Genetically-modified Organisms:
PWG1 Genetic elements that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in the Awareness-raising Guidelines.

PWG2 Genetically-modified organisms that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in the Awareness-raising Guidelines.

Technical note: Genetic elements include *inter alia* chromosomes, genomes, plasmids, transposons, and vectors whether genetically modified or unmodified.

Notes:

2. http://www.australiagroup.net/en/control_list/animal.htm
3. http://www.australiagroup.net/en/control_list/plants.htm

AUSTRALIA GROUP PARTICIPANTS

Argentina
Australia
Austria
Belgium
Bulgaria
Canada
Czech Republic
Denmark
European Commission
Finland
France
Germany
Greece
Hungary
Iceland
Ireland
Italy

Japan
Luxembourg
Netherlands
New Zealand
Norway
Poland
Portugal
Republic of Cyprus
Republic Of Korea
Republic of Turkey
Romania
Slovak Republic
Spain
Sweden
Switzerland
United Kingdom
United States

AUSTRALIA GROUP: GUIDELINES FOR TRANSFERS OF SENSITIVE CHEMICAL OR BIOLOGICAL ITEMS

The Government of xxx has, after careful consideration and consistent with its obligations under the BTWC and the CWC, decided that, when considering the transfer of equipment, materials, and technology that could contribute to chemical and biological weapons activities, it will act in accordance with the following Guidelines.

1. The purpose of these Guidelines is to limit the risks of proliferation and terrorism involving chemical and biological weapons (CBW) by controlling transfers that could contribute to CBW activities by states or non-state actors, consistent with Article III of the Biological Weapons Convention, Article I of the Chemical Weapons Convention, and all relevant United Nations Security Council Resolutions. In accordance with Article X of the Biological Weapons Convention and Article XI of the Chemical Weapons Convention, these Guidelines are not intended to impede chemical or biological trade or international cooperation that could not contribute to CBW activities or terrorism. These Guidelines, including the attached Australia Group (AG) control lists and subsequent amendments thereto, form the basis for controlling transfers to any destination beyond the Government's national jurisdiction or control of materials, equipment, and technology that could contribute to CBW activities. The Government will implement these Guidelines in accordance with its national legislation.

2. These Guidelines will be applied to each transfer of any item in the AG control lists. However, it is a matter for the Government's discretion to determine whether and to what extent to apply expedited licensing measures in the case of transfers to destinations it judges possess consistently excellent non proliferation credentials. Vigilance will be exercised in the consideration of all transfers of items on the AG control lists. Transfers will be denied if the Government judges, on the basis of all available, persuasive information, evaluated according to factors including those in paragraph 3, that the controlled items are intended to be used in a chemical weapons or biological weapons program, or for CBW terrorism, or that a significant risk of diversion exists. It is understood that the decision to transfer remains the sole and sovereign judgment of the Government.

3. In fulfilling the purposes of these Guidelines, national export control legislation, including enforcement and sanctions for violations, plays an important role.

4. To fulfill the purposes of these Guidelines, the evaluation of export applications will take into account the following non-exhaustive list of factors:

a) Information about proliferation and terrorism involving CBW, including any proliferation or terrorism-related activity, or about involvement in clandestine or illegal procurement activities, of the parties to the transaction;
b) The capabilities and objectives of the chemical and biological activities of the recipient state;
c) The significance of the transfer in terms of (1) the appropriateness of the stated end-use, including any relevant assurances submitted by the recipient state or end-user, and (2) the potential development of CBW;
d) The assessment of the end-use of the transfer, including whether a transfer has been previously denied to the end-user, whether the end-user has diverted for unauthorized purposes any transfer previously authorized, and, to the extent possible, whether the end-user is capable of securely handling and storing the item transferred;
e) The applicability of relevant multilateral agreements, including the BTWC and CWC.

5. In a manner consistent with its national legislation and practices, the Government should, before authorizing a transfer of an AG-controlled item, either (a) satisfy itself that goods are not intended for reexport; (b) satisfy itself that, if reexported, the goods would be controlled by the recipient government pursuant to these guidelines; or (c) obtain satisfactory assurances that its consent will be secured prior to any retransfer to a third country.

6. The objective of these Guidelines should not be defeated by the transfer of any non-controlled item containing one or more controlled components where the controlled component(s) are the principal element of the item and can feasibly be removed or used for other purposes. (In judging whether the controlled component(s) are to be considered the principal element, the

Government will weigh the factors of quantity, value, and technological know-how involved and other special circumstances that might establish the controlled component or components as the principal element of the item being procured.) The objective of these Guidelines also should not be defeated by the transfer of a whole plant, on any scale, that has been designed to produce any CBW agent or AG-controlled precursor chemical.

7. The Government reserves the discretion to: (a) apply additional conditions for transfer that it may consider necessary; (b) apply these guidelines to items not on the AG control lists; and c) apply measure to restrict exports for other reasons of public policy consistent with its treaty obligations.

8. In furtherance of the effective operation of the Guidelines, the Government will, as necessary and appropriate, exchange relevant information with other governments applying the same Guidelines.

9. The Government encourages the adherence of all states to these Guidelines in the interest of international peace and security.

Further provisions applicable to Australia Group Participants

In addition, participants in the Australia Group, consistent with their obligations under the BTWC and CWC and in accordance with their national legislation have, after careful consideration, decided also to give equal respect to the following provisions.

Catch-All

1. Participant states will ensure that their regulations require the following:

(a) an authorisation for the transfer of non-listed items where the exporter is informed by the competent authorities of the Participant State in which it is established that the items in question may be intended, in their entirety or part, for use in connection with chemical or biological weapons activities;

(b) that if the exporter is aware that non-listed items are intended to contribute to such activities it must notify the authorities referred to above, which will decide whether or not it is expedient to make the export concerned subject to authorisation.

2. Participant states are encouraged to share information on these measures on a regular basis, and to exchange information on catch-all denials relevant for the purpose of the AG.

   No Undercut Policy

3. In accordance with the Group's agreed procedures, a license for an export that is essentially identical to one denied by another AG participant will only be granted after consultations with that participant, provided it has not expired or been rescinded. Essentially identical is defined as being the same biological agent or chemical or, in the case of dual-use equipment, equipment which has the same or similar specifications and performance being sold to the same consignee. The terms of the Group's 'no undercut policy' do not apply to denials of items under national catch-all provisions.

   Common Approaches

4. AG participants implement these Guidelines in accordance with the Group's agreed common approaches on end-user undertakings and chemical mixtures.

   Intra EU Trade. (This provision applies to members of the European Union)

5. So far as trade within the European Union is concerned, each member State of the European Union will implement the Guidelines in the light of its commitments as a member of the Union.

UNSCOM Final Report (1999)

STATUS OF THE VERIFICATION OF IRAQ'S CHEMICAL WEAPONS PROGRAMME (SELECTED TABLES)[1]

January 29, 1999

Table I. Declared Iraqi Chemical and Biological Munitions

1. Munitions declared by Iraq as remaining after the 1991 Gulf War

Iraq's Declarations[1]

*Munition Type (fill)**	*Quantity*	*Accounting Status*
250 gauge aerial bombs (mustard)	1,243	1,233 aerial bombs were accounted for by UNSCOM. They were destroyed by Iraq under UNSCOM supervision during 1992 and 1993.
250 gauge aerial bombs (unfilled)	8,122	1) 7,627 aerial bombs were accounted for by UNSCOM. They were destroyed by Iraq under UNSCOM supervision during 1991 and 1993. 2) About 500 aerial bombs have not been found. According to Iraq, 500 aerial bombs were delivered damaged by a foreign supplier.
500 gauge aerial bombs (mustard)	1,426	1) 980 aerial bombs were accounted for by UNSCOM. They were destroyed by Iraq under UNSCOM supervision in 1992-1993. 2) Remnants of several hundred destroyed aerial bombs from 438 bombs declared by Iraq as destroyed in a fire accident in 1988, were seen by UNSCOM.
500 gauge aerial bombs (unfilled)	422	1) 331 aerial bombs were accounted for by UNSCOM and destroyed by Iraq under UNSCOM supervision. 2) Some 100 aerial bombs have not been found. According to Iraq, 100 aerial bombs were delivered damaged by a supplier.
R-400 aerial bombs (binary components of sarin)	337	1) 337 aerial bombs were accounted for by UNSCOM. 336 bombs were destroyed by Iraq under UNSCOM supervision in 1992. 2) One bomb was removed for analysis outside Iraq by UNSCOM. 3) Evidence of a few R-400 bombs produced by Iraq for BW purposes has been found among 337 CW bombs declared by Iraq.
R-400 aerial bombs (unfilled)	58	58 aerial bombs were accounted for by UNSCOM and destroyed by Iraq under UNSCOM supervision.
DB-2 aerial bombs (unfilled)	1,203	1,203 aerial bombs were accounted for by UNSCOM. They were destroyed by Iraq under UNSCOM supervision during 1992 and 1993.
122-mm rockets (sarin)	6,610	6,454 rockets were accounted for by UNSCOM. They were destroyed by Iraq under UNSCOM supervision during 1992 and 1993.
122-mm rockets (unfilled)	6,880	7,305 rockets were accounted for by UNSCOM and destroyed by Iraq under UNSCOM supervision.
155-mm artillery shells (mustard)	13,000	12,792 shells were accounted for by UNSCOM. They were destroyed by Iraq under UNSCOM supervision in the period 1992-1994.

(continues)

Table I. *(continued)*

1. Munitions declared by Iraq as remaining after the 1991 Gulf War

Iraq's Declarations[1]

*Munition Type (fill)**	*Quantity*	*Accounting Status*
155-mm artillery shells (unfilled)	16,950	1) 1,700 shells were accounted for by UNSCOM and destroyed by Iraq under UNSCOM supervision. 2) In 1998, Iraq presented documents on the conversion of 15,616 shells to conventional munitions. Of these, 1,779 converted shells were accounted for by UNSCOM.
Special missile warheads (sarin/binary components of sarin)	30	1) All 30 warheads were accounted for by UNSCOM. 2) Of those, 29 warheads were destroyed by Iraq under UNSCOM supervision during 1992 and 1993, and 3) One warhead was removed for analysis outside Iraq by UNSCOM.
Sub total of munitions remaining after the 1991 Gulf war	56,281	

[1] Components of special munitions, including boosters and fuzes, are not included in the table. The majority of these components were not presented by Iraq for verification. According to Iraq, single-use components were destroyed unilaterally and dual-use components were used for conventional purposes. UNSCOM was able to verify their disposition partially.

2. Munitions declared by Iraq as destroyed during the 1991 Gulf war

Iraq's Declarations[1]

*Munition Type (fill)**	*Quantity*	*Accounting Status*
500 gauge aerial bombs (CS riot control agent)	116	1) No remnants of destroyed bombs have been found. 2) In 1995, documentary evidence was provided by Iraq that 116 bombs filled with CS had been stored at a facility destroyed during the Gulf war.
R-400 aerial bombs	160	1) In 1992, remnants of bombs consistent with the declared quantity of bombs were seen by UNSCOM. 2) The circumstances of destruction have not been fully clarified.
DB-2 aerial bomb (sarin)	12	1) In 1991, remnants of up to 50 bombs were seen by UNSCOM. 2) In 1996, documentary evidence was found by UNSCOM that DB-2 bombs had also been filled with mustard (which was not declared). In 1997, Iraq stated that only a few bombs were filled with mustard for trials.
122-mm rockets (sarin)	4,660	1) In 1991, two locations were seen by UNSCOM where rockets had been destroyed. Evidence of many destroyed rockets was found. 2) In the period 1991-1998, remnants of about 4,000 rockets were recovered and accounted for by UNSCOM.

(continues)

Table I. *(continued)*

2. Munitions declared by Iraq as destroyed during the 1991 Gulf war

Iraq's Declarations[1] *Munition Type (fill)**	*Quantity*	*Accounting Status*
122-mm rockets (unfilled)	36,500	1) Completely destroyed hangers where rockets had been destroyed were seen by UNSCOM. Evidence of many destroyed rockets was found. Accounting for the remnants was not possible due to the extent of the destruction. 2) In 1995, documentary evidence was provided by Iraq that 36,500 rockets had been stored at a facility destroyed during the Gulf war.
155-mm artillery shells (mustard)	550	1) No evidence has been found of 550 shells declared by Iraq as having been lost shortly after the Gulf war. 2) In July 1998, Iraq provided a progress report on its ongoing internal investigation.
Sub total of munitions destroyed during the 1991 Gulf war[1]	41,998	

[1]20,000 motor bombs filled with the riot control agent CS, which were destroyed during the Gulf war at one of the storage facilities, are not included in the table.

3. Munitions declared by Iraq as destroyed unilaterally

Iraq's Declarations[1] *Munition Type (fill)**	*Quantity*	*Accounting Status*
250 gauge aerial bombs (CS riot control agent)	125	Remnants of bombs consistent with the declared quantity were seen by UNSCOM.
250 gauge aerial bombs (unfilled)	2,000	1) Remnants of 1,400 destroyed bombs were accounted for by UNSCOM. 2) UNSCOM was presented with ingots declared to be from the melting of 600 bombs. The material presented could not be assessed as adequate for proper verification.
R-400 aerial bombs (binary components of sarin)	527	1) Remnants of bombs consistent with the declared quantity were seen by UNSCOM. 2) Iraq presented supporting documents on the destruction of 527 bombs.
R-400 aerial bombs (biological warfare agents)	157	1) In the period 1992-1998, remnants of up to 60 bombs were accounted for by UNSCOM. 2) Supporting documents on the destruction were presented by Iraq (without reference to the type of agents filled into them).
R-400 aerial bombs (unfilled)	308	1) No evidence was presented of 117 bombs declared by Iraq as having been melted. 2) No evidence was presented of 191 melted bombs declared as defective.
122-mm rockets (unfilled)	26,500	1) Remnants of 11,500 rockets destroyed through demolition were seen by UNSCOM. Accounting was not possible due to the state of destruction. 2) UNSCOM was presented with ingots declared to be from the melting of 15,000 rockets. The material presented could not be assessed as adequate for proper verification.

(continues)

Table I. *(continued)*

3. Munitions declared by Iraq as destroyed unilaterally

Iraq's Declarations[1]

*Munition Type (fill)**	*Quantity*	*Accounting Status*
Special missile warheads (binary components of sarin/biological warfare agents)	45	1) In the period from 1992 to 1998, remnants of 43-45 special warheads were recovered and accounted for by UNSCOM. 2) In the period from 1997 to 1998, remnants of 3 additional warheads declared as special training warheads were recovered. 3) In 1998, degradation products of CW agent VX were found on some of the remnants of special warheads. 4) Supporting documents were provided by Iraq on the overall accounting for special warheads and on the unilateral destruction of 45 warheads.
Sub total of munitions destroyed unilaterally	29,662	

Table II. Iraqi Declared Bulk Agents

1. Iraqi declared bulk chemical warfare (CW) agents (not weaponized)

Bulk agent type	*Quantity (tonnes)*	*Accounting Status*
Mustard ($20m^3/1m^3$ containers)	295	295 tonnes of mustard were destroyed by Iraq under UNSCOM supervision.
Tabun (GA) nerve agent ($2m^3$ containers)	76	76 tonnes of tabun were destroyed by Iraq under UNSCOM supervision.
Sarin (GB) nerve agent and its mixtures ($2m^3$ containers)	40	40 tonnes of tabun were destroyed by Iraq under UNSCOM supervision.
VX nerve agent ($1m^3$ containers)	1.5	1) According to Iraq, 1.5 tonnes of VX were discarded unilaterally by dumping on the ground. 2) Traces of one VX-degradation product and a chemical known as a VX-stabilizer were found in the samples taken from the VX dump sites. 3) A quantified assessment is not possible.
Total	412.5	

Material Balance of key CW Precursor Chemicals

1. Iraq declared that some 20,150 tonnes of key precursor chemicals had been produced by Iraq and procured from abroad for the production of CW agents during the entire period of the implementation of its CW programme.
2. According to Iraq, of the declared total quantity of over 20,000 tonnes of key precursors, 14,500 tonnes were used either for the production of CW agents or for the production of other key precursors for these CW agents. The rest, 5,650 tonnes, was not used in the production of CW agents, and therefore needs to be accounted for separately.
3. Iraq's declarations on its total holdings of key precursors over the period of 8 years could not be fully verified due to the absence of sufficient evidence provided by Iraq and its foreign suppliers for Iraq's procurement and the consumption of key precursors in the production of CW agents prior to 1988, as declared by Iraq.
4. Iraq declared that 3,915 tonnes of key precursors remained in Iraq as of January 1991. According to Iraq, the discrepancy between calculated quantities of precursors left over from the production of CW agents (5,650

tonnes) and quantities of precursors declared by Iraq as remaining in January 1991 (3,915 tonnes) could have occurred due to the lack of sufficient information and full records on the actual delivery by former suppliers, on the consumption of precursors in the production of CW agents, and on the losses of key precursors, including through unsuitable storage, spillage, leakage etc.

5. 3,915 tonnes of key precursors remaining in January 1991 have been accounted for as follows:

- 2,850 tonnes were accounted for by UNSCOM. Of these, 2,610 tonnes of key precursors were destroyed under UNSCOM supervision
- 823 tonnes were declared by Iraq as having been destroyed during the Gulf war. The Commission was able to confirm qualitatively the destruction of these precursors. It was not possible to make a quantitative verification
- 242 tonnes were declared by Iraq as having been destroyed unilaterally in the summer of 1991. These include all precursors for the production of VX. The declared destruction of these 242 tonnes of key precursors was only partly accounted for.

1. The material balance of 3,915 tonnes of key precursors declared by Iraq remaining as of January 1991 is provided in table III.

Table III. Iraqi declared CW agent precursors

1. Precursor declarations.

CW precursor (related CW agent)	*Quantity of key precursor left over from production of CW agents in tonnes (calculated quantity)*	*Quantity of key precursor destroyed during the Gulf War (1991)*	*Quantity of key precursor destroyed unilaterally by Iraq in summer 1991*	*Key precursors physically remaining in Iraq and destroyed under UNSCOM supervision, tonnes*
D4 (tabun)*	166	None	None	166
$POCl_3$ (tabun)**	477	None	None	576
Dimethylamine hydrochloride (tabun)	295	30 1) Evidence of destruction was seen by UNSCOM. 2) Accounting was not possible due to the state of destruction.	None	272 tonnes were destroyed under UNSCOM supervision.
Sodium cyanide (tabun) **	371	None	None	180 tonnes were destroyed under UNSCOM supervision.
Thiodiglycol (mustard)*	377	120 1) Evidence of destruction was seen by UNSCOM. 2) Accounting was not possible due to the state of destruction.	None	188 tonnes were destroyed under UNSCOM supervision.
Thionylchloride* (mustard, GB, GF and VX) **	None	100 1) Evidence of destruction was seen by UNSCOM 2) Accounting was not possible due to the state of destruction.	None	282 tonnes were destroyed under UNSCOM supervision.

(continues)

Table III. *(continued)*

1. Precursor declarations.

CW precursor (related CW agent)	*Quantity of key precursor left over from production of CW agents in tonnes (calculated quantity)*	*Quantity of key precursor destroyed during the Gulf War (1991)*	*Quantity of key precursor destroyed unilaterally by Iraq in summer 1991*	*Key precursors physically remaining in Iraq and destroyed under UNSCOM supervision, tonnes*
PCl_3 (mustard, GB, GF and VX) **	2,422	None	None	650 tonnes were destroyed under UNSCOM supervision.
MPF (GB, GF)*	67	9 1) Evidence of destruction was seen by UNSCOM. 2) Accounting was not possible due to the state of destruction.	30 1) Evidence of destruction was seen by UNSCOM. 2) Accounting was not possible due to the state of destruction.	20 tonnes were destroyed under UNSCOM supervision.
HF (GB, GF) **	181	None	None	1) 11 tonnes were destroyed under UNSCOM supervision. 2) About 200 tonnes were released by UNSCOM for civilian use. 60 tonnes thereof have already been consumed and 140 tonnes remain under UNSCOM monitoring.
Isopropanol (GB)**	465	None	None	445 tonnes were destroyed under UNSCOM supervision.
Cyclohexanol (GF)	120	105 1) Evidence of destruction was seen by UNSCOM 2) Accounting was not possible due to the state of destruction.	None	Tens of tonnes were consumed by Iraq in the 1990s for civilian purposes under UNSCOM supervision.
P_2S_5 (VX)	242	85 1) Evidence of destruction was seen by UNSCOM. 2) 168 empty barrels (200L) from P_2S_5 sufficient for 34 tonnes were accounted for by UNSCOM.	157 1) Evidence of destruction was seen by UNSCOM. 2) 153 tonnes were accounted for by UNSCOM.	None

(continues)

Table III. *(continued)*

1. Precursor declarations.

CW precursor (related CW agent)	*Quantity of key precursor left over from production of CW agents in tonnes (calculated quantity)*	*Quantity of key precursor destroyed during the Gulf War (1991)*	*Quantity of key precursor destroyed unilaterally by Iraq in summer 1991*	*Key precursors physically remaining in Iraq and destroyed under UNSCOM supervision, tonnes*
Diisopropylamine (VX)	210	174 1) Evidence of destruction was seen by UNSCOM. 2) Accounting was not possible due to the state of destruction.	22 tonnes were destroyed under UNSCOM supervision.	None
Chloroethanol (VX)	202	200 1) Evidence of destruction was seen by UNSCOM. 2) Accounting was not possible due to the state of destruction.	None	2 tonnes were destroyed under UNSCOM supervision.
Iraqi Choline (VX)*	55[113]]	None	55[13] 1) UNSCOM took samples from the dump site. 2) Degradation products of choline were found in the samples. 3) Accounting was not possible due to the state of destruction.	None
Sub total	5,650[2]	823	242	2,810

[1]Quantities of key precursors declared by Iraq in 1995 as having been destroyed unilaterally in 1991.
[2]Only key precursors that Iraq declared as remaining as of January 1991 are included in the column. The following key precursors, according to Iraq, were fully consumed prior to 1991: DMMP, MPC, TMP, MPS, and they are not included in the table.
* Key precursors, which Iraq was able to produce indigenously in varying quantities (including DMMP, MPC, MPS and TMP).
** According to Iraq, discrepancies in rows # 2, 4, 6, 7, 9, 10 between calculated quantities of precursors left over from the production of CW agents (column 3) and quantities of precursors presented by Iraq (column 6) could have occurred due to the lack of sufficient information and/or proper record keeping:

a) on the actual delivery of precursors by foreign suppliers,
b) on the actual consumption of precursors in the production of CW agents, and
c) on the losses of key precursors, including through unsuitable storage, spillage, leakage etc.

2. Iraqi declared CW agent production equipment

Production Plant/Unit (Location and past use)	*Iraqi declarations on quantities of key equipment in their original configuration*	*Accounting status*
Mustard plant, P8, Muthanna State Establishment (MSE) production of mustard, attempts to produce VX nerve agent	22	1) The majority of equipment was destroyed during the Gulf war. 2) 12 remaining pieces were destroyed under UNSCOM supervision.

(continues)

Table III. *(continued)*

2. Iraqi declared CW agent production equipment

Production Plant/Unit (Location and past use)	*Iraqi declarations on quantities of key equipment in their original configuration*	*Accounting status*
Tabun/sarin plant and hydrolysis plant, P7 (MSE), production of tabun (GA) and sarin (GB) nerve agents.	16+20	1) Equipment was partly destroyed during the Gulf war. 2) The hydrolysis plant was used for the destruction under UNSCOM supervision of tabun, sarin and their precursors. After the completion of the destruction of sarin, the remaining 17 pieces of equipment were destroyed under UNSCOM supervision.
Multipurpose plant, Dhia (MSE), production of precursors (MPS), production of VX.	42	1) A few pieces of equipment were destroyed during the Gulf war. 2) 39 remaining pieces of equipment were destroyed under UNSCOM supervision.
Multipurpose plant, Malek (MSE), production of precursors (DMMP, MPC, MPS, choline), production of tabun (GA) and VX nerve agents.	25	1) All equipment was damaged during the Gulf war. 2) 24 broken pieces of equipment were accounted for by UNSCOM.
Multipurpose plant, Mohammed (MSE), production of precursors (D4, MPC), production of tabun (GA) nerve agent.	32	1) All equipment was destroyed or damaged during the Gulf war. 2) 25 broken pieces of equipment were accounted for by UNSCOM.
Multipurpose plant, A1 (MSE), production of nerve agent precursors (MPC, MPF).	33	1) All equipment was destroyed or damaged during the Gulf war. 2) 7 remaining pieces of equipment were destroyed under UNSCOM supervision. 3) 26 broken pieces of equipment were accounted for by UNSCOM.
Multipurpose plant, A2 (MSE), production of nerve agent precursors (MPF), production of sarin (GB).	29	1) Equipment was partly destroyed during the Gulf war. 2) 14 remaining pieces of equipment were destroyed under UNSCOM supervision.
Nerve agent precursor plant, TMP (Fallujah 2), construction was not completed.	15	All equipment was completely destroyed during the Gulf war.
Inhalation chamber (MSE)	1	Destroyed under UNSCOM supervision.
Equipment stores	85	85 pieces of equipment were destroyed under UNSCOM supervision.
Aerial Bomb Workshop (MSE)	100	100 pieces of equipment were destroyed under UNSCOM supervision.
Filling station (MSE)	5	1) 4 pieces of equipment were completely destroyed during the Gulf war. 1) 1 unit was destroyed under UNSCOM supervision.

(continues)

Table III. *(continued)*

2. Iraqi declared CW agent production equipment *Production Plant/Unit (Location and past use)*	*Iraqi declarations on quantities of key equipment in their original configuration*	*Accounting status*
Total	553	1) 405 pieces of equipment were destroyed under UNSCOM supervision. 2) 75 pieces of broken equipment damaged during the 1991 Gulf war were accounted for by UNSCOM. 3) Several tens of pieces of equipment are buried under the debris of production buildings destroyed during the 1991 Gulf war.
Misc.		1) 197 pieces of glass production equipment procured by MSE for pilot plants were admitted by Iraq in 1997 and destroyed under UNSCOM supervision.

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Weapons of Mass Destruction

Volume II: Nuclear Weapons

Weapons of Mass Destruction

An Encyclopedia of Worldwide Policy, Technology, and History

Eric A. Croddy and James J. Wirtz, Editors

Jeffrey A. Larsen, Managing Editor

Foreword by David Kay

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Foreword

David Kay

Senior Research Analyst, Potomac Institute, Washington, D.C., and former Director, Iraq Survey Group (2003–2004)

The importance of this encyclopedia was underscored by the fact that virtually the only area of agreement in the 2004 U.S. presidential campaign between the two major candidates, President George W. Bush and Senator John F. Kerry, was that the proliferation of weapons of mass destruction poses the most serious national security threat with which the next president would have to deal.

While the prospect of chemical, biological, radiological, or nuclear weapons falling into the hands of terrorists or regimes hostile to the United States and its friends is indeed a frightening prospect, how many of us understand exactly what this means? When were such weapons first developed? Which states and scientists are leading these developments? Have these weapons actually been used in the past? How often and with what consequence—not only for the populations they were used against, but for those that used them, as well? Do these weapons really give states a decisive edge over their adversaries? How easy are they to develop and use? Does the ease of development or use of such weapons by states, like North Korea, differ from the obstacles faced by terrorist groups, like al-Qaeda? What are the tools available to the United States to halt the spread of such weapons? Have we had any success in limiting the spread of these weapons? Are there any protective measures that individuals can take to lessen their vulnerability if such weapons are used?

These are but a few of the questions that the authors of this authoritative two-volume study attempt to answer. This encyclopedia will have enduring importance as states and societies attempt to come to terms with the consequence of the collision of scientific progress with the failure to develop a reliable global security structure. The initial development of chemical, biological, and nuclear weapons, as this study makes clear, often involved scientific and engineering breakthroughs of the highest order. The paths to enriching uranium and genetically modifying pathogens are but two examples of such successes, scientific breakthroughs that have made new classes of weapons possible. But scientific progress marches at a very fast rate, leaving behind old, but still dangerous, knowledge. For example, the secrets regarding methods for enriching uranium were simply bought by the Iraqis from the U.S. Government Printing Office. That office could not imagine that there was anything important in a 40-year-old project from the dawn of the U.S. nuclear program.

In another remarkable case, uranium enrichment technology was stolen from a commercial company in Holland by A. Q. Khan—a rather ordinary Pakistani who went to Germany to earn an engineering degree. Khan subsequently used this technology to develop Pakistan's nuclear weapons and then sold the same technology to North Korea, Iran, and Libya. The techniques of gene modification, which less than 20 years ago were the stuff of Nobel prizes, are now routinely taught in American high schools and community colleges and have opened up whole new classes of biological weapons. As this study also makes clear, even the safe disposal of weapons of mass destruction following a state's decision to abandon or limit their programs presents serious challenges of preventing the weapons and associated technology from falling into the hands of terrorists. The thousands of Soviet-era nuclear weapons and the engineering talent that created them represent a clear and present danger with which the world has not yet completely dealt. The readers of this work will find numerous examples of the lowering of the barriers to the acquisition by states and terrorists of these most terrible of weapons.

But this study does not simply present the horrors of a world filled with weapons of mass destruction. It also catalogs and illuminates the various methods of attempting to control and constrain these weapons—including treaties and agreements such as the Nuclear Non-Proliferation Treaty and the Chemical Weapons Convention, as well as intrusive inspections, such as the efforts of the United Nations to hunt such weapons in Iraq after the first Gulf War. As will be clear to the reader, such endeavors have had both successes and failures. Much remains to be done to ensure that their effectiveness matches the problems posed by the proliferation of such weapons. The largest gap in effective mechanisms of control and response to the acquisition of such weapons is with regard to the efforts of terrorists groups to acquire the means of mass murder. While these volumes identify the few efforts made in this regard, it is hard not to come away with a sense of dread for the future. Most control efforts have been aimed at states, not at terrorists operating outside of the control of states. Hopefully students and policy makers using this book a few years hence will be able to record more progress toward meeting this new challenge.

The authors and editors have done an important service by pulling together such an illuminating study at exactly the point when there is a broad political consensus of the importance of the problem. One can only hope that our citizens and our political leaders take the time to explore the depth of information presented here.

Preface: Weapons of Mass Destruction

Eric A. Croddy and James J. Wirtz

The term "weapon of mass destruction" (WMD) is a relatively modern expression. It was probably first used in print media following the international uproar over Germany's aerial bombardment of the Basque city of Guernica in April 1937. (The latter event was famously depicted in Picasso's painting *Guernica y Luno.*) Only a year before, another Axis power, Italy, had begun using mustard and other chemical warfare (CW) agents in Abyssinia (modern-day Ethiopia).[1] During the anxious years leading up World War II, WMD referred to the indiscriminate killing of civilians by modern weaponry, especially aircraft. It also echoed the fear of chemical weapons that was unleashed by World War I, which had come to a conclusion just a few years earlier.

Following the development of the atomic bomb in 1945, the term "WMD" came to include nuclear and eventually biological weapons. WMD was apparently first used to describe nuclear warfare by Soviet strategists. In 1956, during the 20th Communist Party Congress in Moscow, the Soviet Minister of Defense—and "Hero of Stalingrad"—Marshal Georgy Konstantinovich Zhukov prophesied that modern warfare "will be characterized by the massive use of air forces, various rocket weapons and various means of mass destruction such as atomic, thermonuclear, chemical and bacteriological weapons."[2] In that same year, the Hungarian Minister of Defense echoed Marshal Zhukov, stating that "Under modern conditions, the decisive aspect of operational planning is the use of nuclear and other weapons of mass destruction."[3]

When the West learned of Zhukov's speech, national security strategists in the United States and elsewhere became quite concerned. By inference, they concluded that WMD—nuclear, biological, and chemical weapons—were an integral part of Soviet military doctrine. Partly in response to Zhukov's ministrations on WMD, the United States reviewed its offensive chemical and biological weapons program in 1958. The U.S. military was never particularly enamored by chemical or biological weapons and treated them as a deterrent to be used in retaliation for the use of chemical or biological weapons used by the opponent. By the early 1990s, the U.S. military had abandoned offensive use of these weapons, although it maintained a research and development program designed to produce effective equipment, procedures, medications, and inoculations to defend against chemical and biological attack.

Over the last decade, much has been written about WMD. The meaning of the term itself is somewhat controversial, although there is a formal, legalistic definition. According to U.S. Code Title 50, "War and National Defense," per the U.S. Congress, the term "weapon of mass destruction" means "any weapon or device that is intended, or has the capability, to cause death or serious bodily injury to a significant number of people through the release, dissemination, or impact of toxic or poisonous chemicals or their precursors; a disease organism; radiation or radioactivity."[4] For its part, the U.S. Department of Defense has a similar characterization of WMD, although in addition it includes " . . .the means to deliver [WMD]."[5] So, what makes a weapon massively destructive? Is it the type of injurious agents involved, namely radioactive, chemical, or biological, or is it that the attack itself produces significant casualties or destruction? Also what would "significant" mean in this context: ten, a hundred, or a thousand casualties? What if very few people are actually killed or hurt by at attack? In the latter respect, the U.S. Federal Bureau of Investigation has a rather unique and somewhat satisfying interpretation of the term "WMD," invoked when the U.S. government indicted Timothy McVeigh with using a WMD in his 1995 terrorist attack in Oklahoma City. In this case, although the device used was a conventional bomb (employing ammonium nitrate-fuel oil explosive), "A weapon crosses the WMD threshold when the consequences of its release overwhelm local responders."[6]

Some analysts, however, have suggested that various technical hurdles prevent chemical and even biological weapons from causing casualties on a truly massive scale. Some point to the Aum Shinrikyo sarin attack on the Tokyo subway system on March 20, 1995, which resulted in eleven deaths, as an example of the *limits* of WMD. They note that high-explosives have been used with far greater lethal effects than sarin in the annals of modern terrorism. Others are increasingly concerned about the destructive potential of even rudimentary weapons. Analysts today are worried, for instance, that terrorists might try to employ radiological dispersal devices or "dirty bombs." These weapons do not detonate with a fission reaction, but rather utilize conventional explosives to distribute radiological materials and contaminate a given area. Few deaths are likely to result from the effects of a dirty bomb, but the consequences—in terms of anxiety, clean-up, and the recognized ability of a terrorist to conduct the very act itself—would likely be far reaching.

About the Encyclopedia

The very presence of chemical, biological and nuclear weapons in international arsenals and the potential that they might fall into the hands of terrorist organizations guarantees that weapons of mass destruction will be of great policy, public, and scholarly interest for years to come. We cannot resolve the debates prompted by WMD, but we hope that we and our contributors can provide facts to help the reader sort through the controversies that are likely to emerge in the years ahead. Much that is contained in these volumes is disturbing and even frightening; it is impossible to write a cheery encyclopedia about weapons whose primary purpose is to conduct postindustrial-scale mass murder. The sad truth of the matter is that chemical, biological, radiological, and nuclear weapons reflect the willingness of humans to go to great lengths to find increasingly lethal and destructive instruments of war and violence. We are pleased to note, however, that much of what is reported in these volumes is historical in nature and that civilized people everywhere reject the use of chemical and biological weapons. International law is replete with treaties, agreements, and regimes whose purpose is to proscribe the use of these weapons, or mitigate the consequences of any such use. In particular, the world has successfully kept nuclear weapons in reserve for almost sixty years as truly deterrent weapons of last resort.

Our encyclopedia covers a wide range of topics, some historical, some drawn from today's headlines. We describe many of the pathogens, diseases, substances, and machines that can serve as weapons of mass destruction, as well as their associated delivery systems. We also describe important events and individuals that have been influential in the development of weapons of mass destruction and doctrines for their use (or control). We have encouraged our contributors to highlight ongoing controversies and contemporary concerns about WMD and current international arms control and nonproliferation efforts intended to reduce the threat they pose to world peace and security. Even a work of this length, however, cannot completely cover the history, science, and personal stories associated with a topic of this magnitude, so we have included abundant references to help readers take those initial steps for further study of the topics we survey.

Acknowledgments

Our deepest debt is to the contributors who made this volume a reality. Many of them joined the project at its inauguration several years ago and have waited a long time to see their work in print. It is impossible for just three people to be experts on all of the subjects covered in this volume, and without the hard work of our contributors, this encyclopedia would never have been completed. Thanks to our research assistants, Abraham Denmark and Laura Fontaine, who uncovered most of the key documents in both volumes and wrote a few entries for us, as well. We also want to express our appreciation to a senior government official who reviewed Volume II for accuracy and sensitive material. We owe a special debt to Jeff Larsen, our managing editor, whose help was instrumental in the success of this project. Not only did he provide editorial support to both volumes, but he displayed a keen ability to deal with the publisher and our 95 contributors, keep track of timelines, requirements, and progress, and gently push the two of us when we needed encour-

agement during this multiyear project that involved over 500 separate parts. Finally, we also want to express our appreciation to Alicia Merritt, Martha Whitt, Giulia Rossi, and the behind-the-scenes copyeditors at ABC-CLIO who worked tirelessly to help get this manuscript into print. We discovered that nothing is a trivial matter when it comes to a manuscript of this size. The commitment of our publisher to this topic, and the dedication of the production staff at ABC-CLIO, greatly facilitated the completion of these volumes.

We hope that this encyclopedia will help inform the public debate about weapons of mass destruction and international security policy, with the goal of never again seeing such weapons used in anger.

Notes

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Sentinel Antiballistic Missile System
Short-Range Attack Missiles (SRAM)
Shrouding
Silo Basing
Single Integrated Operational Plan (SIOP)
Skybolt
South African Nuclear Weapons Program
South Korean Nuclear Weapons Program
Space-Based Infrared Radar System (SBIRS)
Spartan Missile
Sprint Missile
Sputnik
Standing Consultative Commission (SCC)
Stealth Bomber (B-2 Spirit)
Stockpile Stewardship Program
Strategic Air Command (SAC) and Strategic Command (STRATCOM)
Strategic Arms Limitation Talks (SALT I and SALT II)
Strategic Arms Reduction Treaty (START I)
Strategic Arms Reduction Treaty (START II)
Strategic Defense Initiative (SDI)
Strategic Defenses
Strategic Forces
Strategic Offensive Reductions Treaty (SORT)
Strategic Rocket Forces
Submarines, Nuclear-Powered Ballistic Missile (SSBNs)
Submarine-Launched Ballistic Missiles (SLBMs)
Sufficiency
Superiority
Surety
Surprise Attack Conference
Surveillance

Survivability

Tactical Nuclear Weapons
Telemetry
Terminal Phase
Theater High Altitude Air Defense (THAAD)
Theater Missile Defense
Thermonuclear Bomb
Three Mile Island
Three-Plus-Three Program
Threshold States
Threshold Test Ban Treaty (TTBT)
Tinian
Titan ICBMs
Tous Asimuts
Transporter-Erector-Launcher
Triad
Trident
Trinity Site, New Mexico
Tritium
Two-Man Rule

U-2
Underground Testing
Unilateral Initiative
United Nations Special Commission on Iraq (UNSCOM)
United States Air Force
United States Army
United States Navy
United States Nuclear Forces and Doctrine
Uranium

Verification

Warfighting Strategy
Warhead
Warsaw Pact
Wassenaar Arrangement
Weapons-Grade Material
Weapons of Mass Destruction (WMD)

X-Ray Laser

Yield

Zangger Committee
Zone of Peace

Introduction: Nuclear Weapons

James J. Wirtz

On July 16, 1945, the world changed forever when British and American scientists and engineers tested an implosion-type atomic device in the desert near Alamogordo, New Mexico, producing the first nuclear explosion. Developed under the code name "Manhattan Project," this first-generation fission device was quickly weaponized, and when the U.S. Army Air Corps dropped atomic bombs on the Japanese cities of Hiroshima and Nagasaki in August 1945, World War II in the Pacific came to an end. The United States did not retain a nuclear monopoly for long. The Soviet Union detonated a nuclear device in 1949. By the early 1950s, a second generation of fusion weapons, with explosive power measuring in millions of tons of trinitrotoluene (TNT), was entering Soviet and U.S. nuclear arsenals. As the Cold War unfolded, the Soviet and U.S. militaries deployed tens of thousands of tactical, theater, and strategic nuclear weapons to deter both conventional and nuclear attacks. Soviet-American strategic relations reflected a situation of mutual assured destruction (MAD), which moderated superpower behavior but risked catastrophic destruction if some military or diplomatic insult upset the delicate "balance of terror." People everywhere breathed a collective sigh of relief as the risk of nuclear Armageddon became increasingly remote at the end of the Cold War. Since the early 1990s, Russia and the United States have cut the number of their deployed nuclear forces and ended nuclear force modernization and testing. At the turn of the century, it appeared that the threat posed by nuclear weapons was diminishing.

Just as the superpowers pulled back from the nuclear abyss, however, new nuclear threats appeared on the horizon. India and Pakistan tested nuclear weapons in the late 1990s, joining Great Britain, France, and China as overt nuclear powers. It also is widely believed that Israel and North Korea possess a nuclear arsenal. For a time, South Africa possessed a few nuclear weapons, but it renounced its nuclear ambitions and joined the Nuclear Nonproliferation Treaty (NPT) as a non–nuclear weapons state in 1991. Ukraine, Belarus, and Kazakhstan inherited large nuclear arsenals for a short period following the collapse of the Soviet Union in the early 1990s, but all three states were persuaded to give up those weapons and join the NPT by the mid-1990s. Other states have made modest efforts toward acquiring their own arsenals but for various reasons have not yet reached that objective. Nonetheless, some thirty states remain technologically capable of creating atomic weapons fairly quickly should they decide to do so.

The September 11, 2001, terrorist attacks on the World Trade Center and the Pentagon highlighted the fact that terrorists and nonstate actors were interested in creating mass casualty attacks, and many believe that terrorists might be attracted to nuclear or radiological devices as weapons of terror. The risk that any state would employ its nuclear arsenal in a massive nuclear attack is diminishing, but the threat of a small-scale use by some state or nonstate actor is on the rise, especially as nonproliferation efforts fail to prevent the "hard cases" from acquiring nuclear weapons. Officials also worry about the emergence of an international black market in nuclear weapons technology, radiological materials, and even complete weapons. As world history enters the so-called "second nuclear age," nuclear weapons remain a force to be reckoned with, both on the battlefield and in international politics.

Is There a Nuclear Revolution?

Debate about the importance and impact of nuclear weapons on world politics is as fierce now as it was at the dawn of the nuclear era sixty years ago. Nuclear weapons, the advent of long-range delivery systems, and the establishment of a new organization, the U.S. Air Force, produced a revolution in military affairs (RMA) that fundamentally transformed warfare. Bernard Brodie, writing in 1946, was quick to recognize the nature of this RMA when he observed that national objectives for military efforts had changed: Whereas militaries traditionally strove to win wars, with the advent of nuclear weapons their purpose became deterring wars. Nuclear weapons would make major war a calamity, demanding that all military and diplomatic efforts be directed at deterring, by threat of retaliation in kind, nuclear war. Decades later, Robert Jervis (1989) noted that this RMA had produced a nuclear revolution: Stability (the absence of great-power war) now characterized relations between great powers because none dare risk direct military confrontation given the dark shadow of nuclear escalation. There were warnings that this nuclear stability might actually increase the likelihood of smaller wars, however, especially along the "periphery." Glenn Snyder (1961), for instance, identified a "stability-instability" paradox: Stability at the nuclear level of conflict actually made great powers more tolerant of instability (war) in peripheral areas or among clients. But at the end of the Cold War, it did appear that peace, or at least the absence of great-power conflict, was the by-product of the threat of massive nuclear destruction.

Nuclear weapons introduced stability in great-power relations because they produced a modicum of restraint in both diplomatic and military adventures undertaken by Soviets and Americans during the Cold War. Nuclear weapons effects also are predictable, and nuclear powers tend to share a similar knowledge base about the destructiveness of nuclear weapons. Both U.S. and Soviet officials recognized the destructiveness of a full-scale nuclear exchange. Moreover, as Thomas Schelling (1966) noted, the absence of an effective defense against massive nuclear attack allowed nuclear-armed states to engage in the "diplomacy of violence." States armed with large nuclear arsenals could destroy each other's societies while virtually bypassing direct engagement of the opponent's military forces. To a lesser extent than conventional warfare, which is influenced by strategy, tactics, leadership, equipment, training, and morale, the outcome of nuclear combat is driven by the enormous explosive yield of nuclear weapons themselves, not by superior strategy. In other words, once nuclear arsenals became very large and deployed in relatively survivable ways, there was little either the United States or the Soviet Union might do to prevent their opponent from undertaking a nuclear retaliatory strike. MAD was defense dominant because both sides had the ability to deny victory in a nuclear war to the opponent. No nation with a leader in his right mind would start a nuclear war that it would be sure to lose—at least that was the argument advanced by those who championed the nuclear revolution.

Critics of the nuclear revolution have generally come in two varieties: those who believe that it is mistaken to treat deterrence as the dominant nuclear doctrine, and those who believe that nuclear revolutionaries underestimate the risks involved in nuclear deterrence. Those who champion nuclear warfighting strategies believe that others might think nuclear war is winnable or that deterrence itself is unreliable and can fail because of misunderstandings, irrationality, or simple human frailty. Under these circumstances, they believe that for deterrence to be effective, it is imperative to develop credible nuclear warfighting options. Missile defenses that deny opponents the ability to hold U.S. or allied targets at risk thus become an important way to strengthen U.S. deterrent threats. They also believe that nuclear weapons should be integrated into forces and war plans to give national authorities limited nuclear options that could influence battlefield events in positive ways. The 2002 U.S. Nuclear Posture Review, for example, called for the development of highly selective and limited nuclear options to increase the credibility of U.S. deterrent threats and to hold opponents' small nuclear, chemical, and biological weapons arsenals at risk while reducing the prospect of collateral damage.

Other critics worry, however, that the circumstances that make nuclear deterrence "stable" are rare and unlikely to be found in emerging weapons states and regional rivalries. New nuclear weapons states might adopt nuclear doctrines or forces that are shaped by domestic political turmoil, by political dreams of regional domination, or by a specific leader's megalomania. Maintaining negative control over nuclear arsenals (preventing weapons from being used without proper authorization) is daunting in states that face ethnic, fundamentalist, or political unrest. Countries in immediate proximity to each other—here India and Pakistan come to mind—can expect virtually no tactical warning of nuclear attack, increasing the likelihood that they might adopt preventive or preemptive nuclear warfighting strategies. These critics also suggest that building "safe" nuclear weapons is technically challenging and financially demanding and might be beyond the resources of new nuclear powers. No matter what rich or poor states do, "normal accidents," the tendency of complex systems to interact with humans in unanticipated ways, are likely to defeat safety systems.

Those who champion disarmament as the best way to deal with nuclear weapons believe that nuclear deterrence is fundamentally immoral and misguided. Disarmament advocates suggest that those who believe in deterrence or warfighting strategies simply perpetuate a war system that is destined to fail catastrophically. They dismiss ideas about a so-called nuclear revolution as window dressing to justify using a nuclear arms race and threats of nuclear warfare as a means of achieving political objectives. In their view, nuclear weapons are so destructive that they are irrational instruments of war that place at risk far more people and infrastructure than their users can hope to protect. They point out that a full-scale nuclear exchange during the Cold War could have eliminated human beings from planet Earth. Disarmament advocates believe that efforts to develop forces for deterrence create arms races, fear, and hostility and that the only way to break this negative trend is to eliminate nuclear weapons as quickly as possible. Other disarmament advocates believe that nuclear deterrence was epiphenomenal when it came to maintaining stability during the Cold War. They believe that fear of conventional hostilities generally deters war, that most leaders are risk adverse, and often that the spread of democracy throughout the world will soon render nuclear weapons and deterrent strategies obsolete. Others believe that a nuclear taboo—a tradition of nonuse of nuclear weapons—governs the behavior of nuclear weapons states, and that nothing should be done to increase the likelihood that nuclear weapons could or would be used in battle. In general, disarmament advocates see nuclear weapons as simply a highly destructive and dangerous development in humanity's tendency to moderate behavior using threats and violence. They offer diplomacy, mediation, or accommodation as an alternative to nuclear threats to maintain the peace.

Nuclear Weapons Effects: A Primer

Unlike the debate about the political and strategic impact of nuclear weapons, the topic of basic nuclear physics holds few unknowns. The effects that nuclear weapons produce once they are detonated are well documented. A nuclear weapon is the general name given to any device that creates an explosion from energy involving atomic nuclei, either through a fission or a fusion reaction. A gun-type fission weapon is relatively simple to construct; the greatest barrier to obtaining this type of nuclear weapon is the difficulty in manufacturing or obtaining weapons-grade fissile material. By contrast, high-yield, low-weight fusion weapons are some of the most complex machines ever developed by human beings. They combine exquisite mechanical and electrical engineering design and manufacturing with innovative applications of nuclear physics and engineering. The details of specific weapons designs and operating principles are considered top secret by governments around the world.

When a nuclear weapon is detonated, it produces a series of weapons effects that occur in a predictable sequence: electromagnetic pulse (EMP), direct nuclear radiation, thermal radiation (which mostly takes the form of light), blast, and fallout. Bomb designers can vary the way the energy of a nuclear explosion is distributed across these effects. The so-called "neutron bomb," for instance, shifts more energy toward EMP and direct radiation in an effort to reduce collateral damage when used against targets on the ground (such as enemy armored formations) or to maximize damage to the electronic systems of targets in space (such as an opponent's incoming nuclear warheads). Weapons effects vary depending on a variety of influences, including the height of burst (for example, air burst, ground burst, underwater detonation, or underground detonation), weather, and local geography.

EMP and direct radiation are produced immediately upon detonation of a nuclear weapon. EMP is produced by the interaction of gamma radiation and matter that destroys all electronic systems that are not deliberately hardened against its effects. Although EMP effects fall off relatively quickly and are not harmful to humans, high-altitude air bursts can produce a very strong EMP wave that can affect systems thousands of miles away. It is easy to imagine ways that EMP can create indirect casualties as electronic systems necessary to sustain human life or prevent lethal accidents are destroyed by this burst of electronic energy. Although small nuclear weapons are capable of producing direct radiation that is lethal at greater ranges than are reached by other weapons effects, the lethal range of direct radiation for more powerful nuclear weapons is well within the lethal range of blast or thermal radiation produced by the explosion.

About 35 percent of the energy generated by a nuclear explosion takes the form of thermal radiation (in the form of a light pulse). The thermal radiation produced by a relatively large, 1-megaton air burst (a weapon that would have to be detonated at an altitude of about 8,000 feet to prevent the nuclear fireball from touching the ground) can produce first-degree burns on exposed skin at about a distance of 7 miles from the point of detonation, second-degree burns at a distance of about 6 miles, and third-degree burns within a radius of about 5 miles. Third-degree burns over 30 percent of the body will produce shock, a condition that requires immediate medical treatment. This weapon would also produce temporary flash blindness in anyone caught out in the open within about 13 miles on a clear day and within 53 miles on a clear night. The thermal light pulse also can produce retinal burn, causing permanent blindness, but this injury is relatively rare, suggesting those who suffer it probably would be killed by other weapons effects.

Blast, which arrives a few seconds after the light pulse, takes the form of overpressure (a quick rise in atmospheric pressure) and dynamic overpressure (wind). At about 1 mile away from a 1-megaton air burst, overpressure increases to about 20 pounds per square inch (psi) and wind velocities reach a peak of about 470 miles per hour. This is enough to level steel-reinforced concrete structures. At about 5 miles away from the blast, overpressure reaches about 5 psi and wind velocities reach about 160 miles an hour, which is sufficient to destroy lightly constructed commercial buildings and most residences. This "5-psi ring" is an important dividing line in terms of nuclear weapons effects: Planners assume that 50 percent of the people within this ring would be killed promptly by the blast effects of a nuclear weapon. At about 12 miles away from a 1-megaton air burst, overpressure drops to less than 1 psi and wind velocities drop to less than 35 miles per hour, making flying glass and debris the greatest hazard. When planners calculate damage expectancies from nuclear weapons, they generally rely on blast effects, not thermal effects, to predict the damage and casualties that will occur.

Irradiated earth and debris that is carried aloft in a nuclear detonation and then returns to the ground is known as fallout. A nuclear ground-burst intended to destroy hardened targets such as missile silos or underground command facilities would produce the greatest amount of fallout; air bursts intended to destroy area targets such as cities or to barrage-attack the operating areas of land-based mobile missiles would produce the least. How fallout is deposited is highly variable and depends on wind speed and direction, the height to which the fallout is initially lofted by the fireball, weather (rain can wash fallout out of the sky, creating local "hot spots"), and geography (weapons effects can be shaped by local geographic features, such as hills). The amount of radiation produced by fallout will diminish over time as the irradiated materials "decay." Most radioactive materials have short half-lives; in other words, they decay relatively quickly. Highly radioactive materials will decay by a factor of 1,000 in about two weeks. Some radioactive materials, however, have extremely long half-lives: Strontium 90 and cesium 137 remain radioactive for years and can contaminate the food chain, for example.

Exposure to radiation kills at the cellular level. An exposure of 600 rem (Roentgen equivalent man) over about a week has a 90 percent chance of killing an individual; an exposure of 300 rem is probably the minimal dose necessary to create a lethal illness quickly. Individuals who suffer from preexisting medical conditions probably would succumb to radiation sickness or secondary infections at relatively low levels of radiation exposure. Exposure to between 50 and 200 rem interferes with the body's ability to heal itself, increasing the probability that people exposed to nonlethal levels of radiation will die from thermal or kinetic injuries produced by other weapons effects. Exposure to radiation also can have a long-term effect on a population. Exposure to 50 rem would probably increase the occurrence of fatal cancers at a rate of between 0.4 and 2.5 percent among an exposed population (*The Effects of Nuclear War*).

Living with the Bomb

Three methods of dealing with the presence of nuclear weapons have emerged in international relations: deterrence, arms control, and disarmament. Deterrence remains the dominant strategy of nations to prevent the use of nuclear weapons by other states. It creates a state of mind in an adversary that makes an act of aggression on the part of the opponent less likely. States using this strategy must have the capability to retaliate in kind if the opponent uses nuclear weapons and must make credible threats that nuclear retaliation will occur. There is much debate about the effectiveness of deterrence, when it has failed in the past, and under what circumstances it is likely to fail again in the future. During the Cold War, both the Soviet and U.S. militaries went to great lengths to construct secure second-strike forces and command and control facilities that could survive a nuclear attack and strike a retaliatory blow. But as political motivations for war have diminished among nuclear powers over the past couple of decades, many observers believe that a little nuclear deterrence goes a long way toward reducing the likelihood of war.

Negotiations among enemies to take actions of mutual interest—a process that came to be known as arms control—was a revolutionary idea when it reemerged in the 1950s as a way to moderate the nuclear arms race. With the goals of making war less likely, reducing death and destruction if war should break out, and reducing the resources devoted to armament, arms control negotiations achieved some successes during the Cold War. Arms control probably made its greatest contribution by allowing the superpowers to clarify their strategic intentions and expectations and by demonstrating to all concerned that negotiation offered an alternative to violent confrontation as a means of managing the nuclear standoff. Because the "Russian" or "American" threat no longer drives defense planning in Washington or Moscow, traditional approaches to arms control are starting to produce diminishing returns in Russian-American relations. But arms control, especially new types of confidence-building measures, might help to moderate other regional rivalries that have been exacerbated by nuclear proliferation and an accelerating race to develop more advanced nuclear delivery systems.

Disarmament efforts have made modest progress over the past half-century. The Nuclear Nonproliferation Treaty (NPT) serves as the basis of the international nonproliferation regime. The NPT is a means by which states not interested in developing nuclear weapons can register formally their nonnuclear status. It also pressures nuclear powers to take action to reduce not only the size of their nuclear arsenals but also their reliance on nuclear weapons in their military and foreign policies. The nonproliferation regime provides a method for regulating legitimate commerce in nuclear materials, and it provides an inspection and monitoring mechanism run by the International Atomic Energy Agency to guarantee that nuclear materials are not diverted into nuclear weapons production. Revelations of a black market in nuclear materials, technologies, and associated delivery systems, however, have cast doubts on current international efforts to prevent nuclear materials from falling into the wrong hands, especially nonstate actors and terrorist groups.

About Volume II: Nuclear Weapons

Nuclear weapons create a set of ethical, political, and military challenges that are difficult to understand. There are no easy solutions to the problems created by nuclear weapons. Indeed, the nuclear question has concentrated some of the best minds on the planet over the past sixty years. The output of this effort is enough to fill an average municipal library. It is impossible to capture this entire body of knowledge in a single volume, but our contributors have provided matter-of-fact explanations of key concepts and accessible descriptions of events to provide a ready reference for those interested in learning more about nuclear weapons. The more societies know about the true effects and dangers of nuclear weapons, the less likely it will be that nuclear weapons will ever be used in war again.

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Chronology: Nuclear Weapons

The "nuclear age" began at five o'clock on the morning of 16 July 1945 with the detonation of the world's first atomic bomb—the Trinity test in the high desert of central New Mexico. This successful explosion marked the culmination of three years of frantic scientific and engineering research and development under the auspices of the U.S. Manhattan Project, which the United States had instituted in 1942 to ensure that the Allies achieved atomic weapons before Germany. There had been scientific discoveries and research in the field of radiology prior to World War II (primarily in the 1930s), but the threat of an adversary achieving the "ultimate weapon" before the Allies had one was a strong motivating factor in the efforts of the Manhattan scientists.

Following the war the world entered a long twilight period known as the Cold War. The United States and its allies faced off against a seemingly implacable foe, the Soviet Union. Both sides rapidly built up their nuclear arsenals until there were some 60,000 atomic warheads pointed at one another. After years of "standing toe to toe," threatening nuclear war and "looking into the abyss," reason slowly began to enter into the equation. Concepts like arms control and nuclear disarmament began to determine international relations. Stockpile levels were already coming down dramatically by the time the Soviet Union dissolved in 1991, following which the world shifted from a bilateral standoff to a less well-defined era. Despite the fact that there are fewer nuclear weapons today, whether the post–Cold War era will be one our children look back on as "safer" than the Cold War is a question still out for consideration.

The history of the Cold War is replete with events falling into two alternative categories: new developments in weapons design and capabilities as the arms race between the two superpowers accelerated, on the one hand, while on the other, we see attempts to improve relations between the two primary actors on the international scene, involving summit meetings, arms control negotiations and agreements, and force reductions.

In this short chronology we have listed merely some of the highlights of this two-pronged effort over the past seventy years.

1933	Hungarian physicist Leo Szilard theorizes atomic structure.
1938	Otto Hahan and Fritz Strassmann's discovery of fission steers Germany toward developing an atomic weapon.
July 1939	Szilard and Edward Teller meet with Albert Einstein in New York to describe Germany's efforts. Einstein writes letter to President Franklin Roosevelt warning him of the possibility of building an atomic weapon.
Fall 1939	United States grants small funding for research into nuclear fission. Key scientists involved include Szilard, Teller, and Enrico Fermi. Early work is carried out primarily at Columbia University and the Universities of California and Chicago.

1941	By 1941, Germany leads the race for the atomic bomb. They have a heavy-water plant (in Norway), high-grade uranium compounds, a nearly complete cyclotron, capable scientists and engineers, and the greatest chemical engineering industry in the world.
June 1942	The United States begins major research program to develop and build a usable atomic weapon. The effort is called the Manhattan Project, and is directed by Major General Leslie Groves and Robert Oppenheimer.
1942–1943	Three entirely new towns are created for the sole purpose of developing the components of an atomic bomb: Los Alamos, New Mexico (center of scientific and engineering efforts), Oak Ridge, Tennessee (where uranium enrichment is centered), and Hanford, Washington (where plutonium is reprocessed from spent reactor fuel). This is the beginning of what will become a massive American atomic infrastructure.
2 December 1942	At the University of Chicago Fermi oversees the first controlled energy release from the nucleus of the atom using a uranium graphite reactor.
16 July 1945	The United States tests the world's first atomic bomb at the Trinity Site in central New Mexico.
6 August 1945	A United States B-29 bomber drops atomic bomb on Hiroshima, Japan (another bomber drops a second bomb on Nagasaki, Japan three days later).
4 April 1946	United States passes Atomic Energy Act (also known as the McMahon Act), creating the U.S. Atomic Energy Commission (which was absorbed into the United Nations Disarmament Commission in 1952).
14 June 1946	Baruch Plan presented by the United States to the United Nations, an early disarmament effort to place all nuclear material and weapons under UN control. (Proposal is rejected by the USSR in December 1946.)
29 August 1949	Soviet Union tests its first atomic bomb.
1 November 1951	United States tests the world's first hydrogen bomb.
3 October 1952	Great Britain tests its first atomic bomb.
August 1953	Soviet Union tests its first hydrogen bomb.
8 December 1953	United States makes an "Atoms for Peace" proposal to the UN General Assembly.
January 1954	United States launches its first nuclear powered submarine.
23 October 1954	In a protocol to the Brussels Treaty (which created the

	West European Union) and in return for permission to rearm itself with conventional weapons, West Germany pledges not to produce, procure, or possess weapons of mass destruction.
December 1954	The North Atlantic Treaty Organization deploys atomic weapons in Europe.
26 October 1956	International Atomic Energy Agency created.
4 October 1957	USSR launches Sputnik, the world's first orbiting satellite.
15 October 1957	USSR and China sign a defense agreement whereby the Soviets agree to provide China with technical help in developing their own atomic bomb.
10 January 1958	United States tests the world's first intercontinental ballistic missile (ICBM).
31 October 1958	United States, United Kingdom, and USSR begin negotiations on a comprehensive test ban treaty (CTBT).
June 1959	United States launches the first nuclear powered submarine equipped with submarine-launched ballistic missiles (SLBM).
1 December 1959	Twelve nations sign the Antarctic Treaty, demilitarizing the continent, and leading the way to future geographic nuclear weapon free zones.
13 February 1960	France tests its first atomic bomb.
15–28 October 1962	The United States and the Soviet Union come close to nuclear war during the Cuban Missile Crisis.
20 June 1963	United States and Soviet Union establish a crisis communications link by signing the Hot Line Agreement.
5 August 1963	United States, United Kingdom, and USSR sign the Limited Test Ban Treaty, banning nuclear weapon tests in the atmosphere, outer space, and underwater.
1964	United States ceases production of highly enriched uranium.
16 October 1964	China tests its first atomic bomb.
27 January 1967	Outer Space Treaty signed by 67 nations; demilitarizes space and celestial bodies.
14 February 1967	Treaty of Tlatelcolco signed, creating the Latin American Nuclear Weapon Free Zone.
13 December 1967	United States announces that it has successfully tested ICBM warheads with multiple independently targetable reentry vehicles (MIRVs).
1 July 1968	Nuclear Non-Proliferation Treaty (NPT) signed by 73 countries (currently there are 187 states parties to the treaty).

3 September 1971	The Zangger Committee created by 33 nations to voluntarily restrict nuclear-related exports.
30 September 1971	Nuclear War Risk Reduction Agreement signed by the United States and Soviet Union (also called the Accidents Measures Agreement).
26 May 1972	Strategic Arms Limitation Treaty (SALT I) signed in Moscow by the United States and Soviet Union. The first major strategic arms control treaty, it consists of an Interim Agreement on Strategic Offensive Arms (freezing the number of missile launch sites) and an Anti-Ballistic Missile Treaty (ABM) (which restricts the development of missile defenses).
18 May 1974	India tests its first atomic "device."
3 July 1974	United States and Soviet Union sign the Threshold Test Ban Treaty, limiting the size of allowable underground nuclear weapons test explosions.
23 April 1975	The Nuclear Suppliers Group is created to restrict the export of sensitive technology.
1 August 1975	The Helsinki Accords are signed by 35 states, creating the Conference on Security and Cooperation in Europe and emphasizing the value of confidence- and security building measures.
28 May 1976	Peaceful Nuclear Explosions Treaty signed by the United States and USSR.
March 1979	Three Mile Island nuclear power reactor accident in Pennsylvania.
18 June 1979	SALT II Treaty signed by the United States and Soviet Union (limiting the number and types of strategic delivery vehicles allowed); treaty is never ratified.
June 1981	Israeli jets strike Iraqi nuclear reactor in preemptive attack.
23 March 1983	United States announces its strategic defense initiative.
6 August 1985	Treaty of Rarotonga signed, creating the South Pacific Nuclear Free Zone.
April 1986	Soviet nuclear reactors explode and melt down at Chernobyl, Ukraine.
7 April 1987	Missile Technology Control Regime established to reduce proliferation risks through controls on technology transfers.
8 December 1987	Intermediate-Range Nuclear Forces Treaty (INF) signed by the United States and Soviet Union, eliminating an entire category of missiles with a range of 500 to 5,500 kilometers.
1988	United States closes its plutonium production facilities.

9 November 1989	Berlin Wall falls in peaceful revolution; within two years NATO has declared the Cold War over (July 1990) and the Soviet Union disappears (December 1991).
3 April 1991	Following the victory by the U.S.-led international military coalition that defeated Iraq in the Gulf War, the United Nations creates a Special Commission on Iraq (UNSCOM) to find and destroy Iraqi capabilities to make weapons of mass destruction.
9 July 1991	Strategic Arms Reduction Treaty (START I) signed by United States and Soviet Union; limits strategic delivery vehicles on each side.
27 September 1991	United States initiates series of reciprocated Presidential Nuclear Initiatives that eliminate or remove most tactical nuclear weapons systems from deployment and lead to the de-alerting or de-targeting of strategic systems.
27 November 1991	U.S. Congress passes Nuclear Threat Reduction Act (also called the Nunn-Lugar Program) to help the Soviet Union transport, store, safeguard, and destroy its residual nuclear arsenal; leads to creation of the Cooperative Threat Reduction Program.
20 January 1992	North and South Korea sign the Joint Declaration on the Denuclearization of the Korean Peninsula.
24 March 1992	Treaty on Open Skies signed by 25 nations to allow intrusive aerial reconnaissance for arms control monitoring and compliance verification.
23 September 1992	Last U.S. underground nuclear test.
3 January 1993	START II Treaty signed by the United States and Russia; further limits number of strategic delivery systems and eliminates warheads with multiple independently targetable reentry vehicles (MIRV) and heavy ICBMs.
14 January 1994	United States, Russia, and Ukraine sign Trilateral Agreement, whereby Ukraine agrees to return to Russia nuclear weapons left on its territory upon the demise of the Soviet Union.
24 March 1994	South Africa admits it had a secret nuclear weapons program that since 1974 had produced six weapons, now destroyed.
30 May 1994	United States and Russia agree to detarget their ICBMs and SLBMs away from each other's territory. Russia concludes similar agreements with Great Britain and China.
23 June 1994	United States and Russia sign agreement on shutting down Russia's plutonium production facilities (also

	called the Gore-Chernomyrdin Agreement).
22 September 1994	United States releases its Nuclear Posture Review, calling for a smaller version of the Cold War nuclear triad.
23 October 1994	United States and North Korea sign Agreed Framework to stop North Korea's attempts to develop nuclear weapons in return for food and energy assistance.
23 March 1995	Fissile Material Cutoff Talks begin in the UN Conference on Disarmament.
12 May 1995	States parties to the NPT Extension Review conference agree to extend the treaty indefinitely
15 December 1995	Treaty of Bangkok signed, creating the Southeast Asian Nuclear Weapons Free Zone.
11 April 1996	Pelindaba Treaty signed, creating the African Nuclear Weapons Free Zone.
10 September 1996	UN adopts the Comprehensive Test Ban Treaty (the United States is the first country to sign it, but the U.S. Congress refuses to ratify it on 13 October 1999).
21 March 1997	United States and Russia agree on parameters for START III negotiations (which never occur).
11 May 1998	India tests atomic weapons.
28 May 1998	Pakistan tests its first atomic weapon.
22 September 1998	United States and Russia begin Nuclear Cities Initiative to provide nonmilitary work for Russian scientists and engineers formerly involved in the nuclear weapons complex
December 2001	United States releases Nuclear Posture Review, calling for a new triad consisting of strategic strike forces, missile defenses, and an enhanced infrastructure.
24 May 2002	United States and Russia sign Strategic Offensive Reductions Treaty (SORT, also known as the Moscow Treaty), calling for reductions in deployed strategic warheads to approximately 2,000 by 2012.
13 June 2002	United States withdraws from the ABM Treaty, citing a need to develop and deploy a working antiballistic missile system.
27 June 2002	G-8 countries agree to a Global Partnership against the Spread of Weapons and Materials of Mass Destruction.
5 October 2002	North Korea admits it has an ongoing nuclear weapons program in defiance of its responsibilities under the NPT.
September 2003	Proliferation Security Initiative signed by 11 countries.

A

ACCIDENTAL LAUNCH PROTECTION SYSTEM
See Strategic Defense Initiative

ACCIDENTAL NUCLEAR WAR

An accidental nuclear war would be one resulting from the use of nuclear weapons without the approval of legitimate political or military authorities in decision-making processes evaluating the need for a nuclear attack or retaliation in light of national security concerns. Several potential causes of accidental nuclear war have emerged in the literature.

An accidental war could be caused by the malfunction of some weapon system or from human error involved in the operation of a weapon. In terms of operator error or equipment malfunction, weapons literally would begin to launch or detonate "accidentally," a scenario that could lead to a nuclear exchange, especially in time of crisis. Although many procedures are followed to maintain negative control of nuclear weapons (that is, to guarantee that they will not be used without orders), highly complex systems can interact in unexpected ways, defying the best efforts of operators to maintain or regain control. During the Cold War, for example, observers worried that the Soviet and U.S. early warning networks and command and control systems actually formed a single and tightly linked mechanism that might produce a "ratcheting effect" in time of crisis, generating a feedback loop that would force both sides to take steps greatly increasing the prospect of war. Another concern was that early warning data could be mislabeled or misinterpreted, leading to a mistaken decision to retaliate.

"Inadvertent war" is sometimes used interchangeably with the term "accidental war," but it identifies a different phenomenon. Inadvertent war is caused by the close interaction of opposing military forces in peacetime or during a crisis. Fighting erupts as a result of locally rational decisions or mistakes made by local commanders, decisions that effectively disconnect the use of force from political control. Inadvertent war is not accidental in the sense that it is caused by mechanical failure or operator error; rather, it is caused by the tendency of military interactions to unfold according to their own logic.

Since the dawn of the nuclear era, substantial thought and effort have gone into preventing accidental and inadvertent nuclear war. Nuclear powers have attempted to construct the most reliable technology and procedures for command and control of nuclear weapons, including robust, fail-safe early warning systems for verifying attacks. The United States and the Soviet Union also maintained secure second-strike capabilities to reduce their own incentives to launch a preemptive strike against each other during crisis situations or out of fear of a surprise attack. The two nuclear superpowers worked bilaterally to foster strategic stability by means of arms control and confidence-building measures and agreements. Several confidence-building agreements were negotiated between the two superpowers to reduce the risk of an accidental nuclear war: the 1971 Agreement on Measures to Reduce the Risk of Outbreak of Nuclear War, the 1972 Agreement on the Prevention of Incidents on and over the High Seas, and the 1973 Agreement on the Prevention of Nuclear War. Following the end of the Cold War, the United States and the Russian Federation have continued to offer unilateral initiatives and to negotiate bilateral agreements on dealerting and detargeting some of their nuclear forces to further reduce the likelihood of a catastrophic nuclear accident. They have concluded agreements on providing each other with notifications in the event of ballistic missile launches or other types of military activities that could possibly be misunderstood or misconstrued by the other party.

The likelihood of accidental nuclear war has always been viewed as low, but the consequences of such a war or incident were, and remain, viewed as so potentially catastrophic as to require serious diplomatic and scholarly attention and analysis. Today, many analysts consider the risk of accidental nuclear war greater than the possibility of a premeditated nuclear exchange between nations. As additional nuclear powers have emerged, so have concerns about the technology and procedures for command and control of nuclear weapons. The proliferation of nuclear weapons has been thought to increase the probability of accidental or inadvertent nuclear war, especially since stability criteria are less obvious in a multiplayer game. In addition, the risks of dramatic political changes in states possessing nuclear weapons, highlighted by the breakup of the Soviet Union and the political fragility of a nuclear-armed Pakistan, leave many observers uneasy about the safety and security of nuclear arsenals amid politically or militarily chaotic situations.

—Steven Rosenkrantz

See also: Reciprocal Fear of Surprise Attack; Surety

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ACCURACY

A weapon's accuracy is usually measured in terms of "circular error probable" (CEP), that is, the radius within which a warhead or bomb will land 50 percent of the time. The lower the CEP, the more accurate the weapon. As technology and delivery systems have improved, CEP for most weapons has shrunk. Early bombs had CEPs only as accurate as the bombardiers or pilots who dropped them. The "precision-bombing" of World War II had CEPs of hundreds or even thousands of feet. Similarly, early cruise missiles and intercontinental ballistic missiles (ICBMs) also had CEPs in the thousands of feet. Because of this, nuclear warhead yield was very large to ensure destruction of a target. Today, accuracy is in the hundreds of feet for modern nuclear weaponry. Precision-guided technology is allowing CEPs as small as a few feet, allowing the use of very low-yield nuclear or conventional warheads to destroy even hard or deeply buried targets.

—Zach Becker

See also: Inertial Navigation and Missile Guidance; Safeguards

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ACHESON-LILIENTHAL REPORT

The Acheson-Lilienthal Report, formally entitled *Report on the International Control of Atomic Energy,* was the first major nuclear proliferation-control document of the post–World War II era. It proposed the establishment of a safeguarding regime for nuclear materials.

The report, released in 1946 by Assistant Secretary of State Dean Acheson and the chairman of the Tennessee Valley Authority, David Lilienthal, was a result of a major effort to understand the global strategic environment following the use of atomic weapons against Japan. The devastation at Hiroshima and Nagasaki sparked immediate fear in the United States about the spread of atomic weapons.

The Acheson-Lilienthal Report also recognized the inherent interrelationship between peaceful and military uses of atomic energy and foresaw that no ban on atomic activities could be enacted without adversely affecting the development of peaceful uses that could benefit humankind. This need to constrain the military use of nuclear technology, on the one hand, while sharing its commercial applications, on the other, is reflected in subsequent nuclear nonproliferation efforts, such as the Nuclear Nonproliferation Treaty of 1968.

The report outlined the critical components of a safeguards regime and distinguished between safe and dangerous nuclear activities in terms of their relationship to the development of nuclear weapons. It also proposed establishing an international authority to monitor the nuclear fuel cycle. This report is an important foundational document for understanding current nonproliferation strategies.

—Jennifer Hunt Morstein

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ACTINIDES

Actinides are a series of heavy elements that are chemically similar to actinium, including uranium and plutonium, the two major elements used in nuclear power and weapons. Actinides include fifteen different elements, ranging from actinium (atomic number 89) to lawrencium (atomic number 103) on the periodic table. Many of these elements are manmade and have half-lives of thousands of years. All of these elements are radioactive, generally emitting alpha and gamma radiation. Other actinides, referred to as minor actinides, include neptunium, americium, and curium. These are produced in nuclear power plants and are present in spent fuel.

Certain unique chemical properties of actinides facilitate the ability to reprocess spent fuel from nuclear power reactors. These chemical properties allow for the extraction of actinides, particularly uranium and plutonium, from spent fuel using a solvent-extraction method. A solvent-extraction method uses water or other solutions to extract elements based on their ability to dissolve in the solution.

The United States does not currently reprocess spent fuel to recover usable fissile material. However, reprocessing methods are being used in France and may be used in the United States in the future. Terrorist organizations and rogue nations may seek to acquire spent fuel with the purpose of extracting actinides.

—Don Gillich

See also: Enrichment; Plutonium; Reprocessing; Uranium

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AIR-LAUNCHED CRUISE MISSILES

See Cruise Missiles

AIRBORNE ALERT

The U.S. alert operation, code-named Chrome Dome, was a realistic training mission designed by the Strategic Air Command (SAC) to deter enemy forces from a surprise attack on the United States. Chrome Dome was established in 1960 following a series of planning and training flights in the late 1950s, and a portion of the U.S. strategic nuclear bombing fleet remained on continuous airborne alert until 1968. In later years, these missions operated under the code names Head Start, Round Robin, and Hard Head. The alert ensured that up to a dozen nuclear-armed bombers were airborne twenty-four hours a day. It also demonstrated SAC's nearly immediate retaliatory capability in case of a Soviet surprise attack, thus strengthening America's nuclear deterrent. Fully combat-configured B-52s carrying nuclear weapons flew routes to points along the Soviet border. The southern route crossed the Atlantic, the Mediterranean, and then returned to the United States; the northern route went up the eastern coast of Canada, across Canada west toward Alaska, then down the west coast of North America. Other mission routes were substituted as required. The Hard Head missions were intended to ensure continuous visual surveillance of Thule Air Base, Greenland, and its vital Ballistic Missile Early Warning System (BMEWS) radar, a critical element for the U.S. response to a Soviet surprise attack on North America. SAC wings launched two combat-ready B-52s every twenty to twenty-three hours for thirty- to sixty-day operations (the duty rotated among SAC's B-52 wings). To keep the B-52s airborne for long periods, KC-135 tankers were launched to keep bombers air-refueled.

Airborne alert flights ended following two serious accidents involving nuclear bombs and B-52s. On January 17, 1966, a B-52 collided with its KC-135 during aerial refueling and crashed off the coast of Palomares, Spain, and on January 22, 1968, a B-52 crashed near Thule, Greenland. SAC thereafter placed 30 percent of its bomber force on ground alert with crews ready to take off within minutes if a warning was received from a BMEWS site or other radar.

—Gilles Van Nederveen

See also: Bombers, Broken Arrow, Bent Spear; U.S. Nuclear-Capable; Strategic Air Command and Strategic Command

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ALPHA PARTICLES
See Radiation

ANTI-BALLISTIC MISSILE (ABM) TREATY
Signed in 1972 between the United States and the Soviet Union, the Anti-Ballistic Missile (ABM) Treaty severely restricted their respective development and deployment of ballistic missile defenses and was considered a significant milestone in the history of arms control. It was the first formal treaty between the two nations limiting systems related to their central strategic deterrent capabilities. The U.S. government at the time portrayed it as a significant first step in a new era of mutual restraint and arms limitation between the Cold War superpowers that would provide for a more stable strategic balance and lead to a broader, more comprehensive series of arms control agreements. The treaty also set important precedents that were followed by later arms control treaties, including the legitimization of "national technical means" of verification and the establishment of a commission to oversee implementation and compliance. Over the course of its existence, from May 26, 1972, until June 13, 2002, the ABM Treaty was viewed by many as the basis of Soviet- and then Russian-American strategic relations. Promoted on the one hand as the cornerstone of strategic stability, and vilified on the other as a constraint on U.S. self-defense that shackled Washington to a strategic doctrine of perpetual vulnerability, the ABM Treaty represented both the best and the worst aspects of modern arms control (*see* Missile Defense).

Negotiation of the Treaty
Soviet leaders were at first opposed in principle to the very idea of negotiating limits on missile defenses—which, after all, were entirely defensive weapons. Within days of the U.S. Senate's June 24, 1968, approval of a major U.S. ABM deployment program (*see* Sentinel Anti-Ballistic Missile System) designed to match the Soviet Union's own ABM system then being deployed around Moscow, however, they did a complete about-face on the subject and agreed to accept the U.S. proposal to begin immediate discussions on limiting ballistic missile defenses. Although the United States was most interested in achieving a treaty on offensive force limitations, following two years of negotiations it accepted a treaty limiting ABM systems along with an interim agreement on offensive arms limitations, with the prospect of pursuing a more comprehensive formal treaty on offensive arms in the future (*see* Strategic Arms Limitation Talks [SALT I and SALT II]).

Terms of the Treaty
The ABM Treaty originally limited the United States and the Soviet Union to two sites of 100 antiballistic missile launchers each, separated by at least 1,300 kilometers. A protocol to the treaty, signed in 1974, reduced this limit to just one site for each side. The treaty banned the deployment of ABM systems for a defense of national territory and obligated the parties not to provide a base for such a defense or for the defense of an individual region, except as provided for in the treaty. ABM systems were defined, for the purposes of the treaty, as ABM interceptor missiles, ABM launchers, and ABM radars. ABM missiles and ABM radars were defined as those "constructed and deployed for an ABM role, or of a type tested in an ABM mode"—a formulation that later posed significant problems of interpretation. The application of the treaty terms to ABM systems that used mechanisms other than missiles to intercept strategic missiles, such as lasers or directed-energy weapons, also became the subject of an intense controversy in the years subsequent to the signing of the treaty.

The ABM Treaty further provided for a complete prohibition on developing, testing, or deploying ABM systems or components that were not fixed and land based, that is, sea-, air-, space-, or mobile land-based systems or components. To reduce the potential for circumventing the terms of the treaty, the treaty also prohibited upgrading theater-range antiballistic missiles (which were not otherwise limited by the treaty), testing them concurrently with strategic ABM systems or components, or transferring ABM systems or components to other nations. ABM radars were limited to those at ABM launcher bases or located on the periphery of the national territory and oriented outward (restrictions violated by the Soviet ABM radar at Krasnoyarsk).

Relationship of the Treaty to Other Treaties
Many ABM Treaty supporters considered it the basis of international arms control regimes, which were all predicated to one degree or another on the assumption that the ABM Treaty had forestalled a U.S.-Soviet arms race between offensive and defensive weapons.

Premier Leonid Brezhnev and President Richard Nixon shake hands in Moscow after signing the Anti-Ballistic Missile Treaty, May 1972. (National Archives)

The Soviets took steps to codify a linkage between their interest in further strategic offensive arms reductions and preservation of the ABM Treaty. For example, they insisted, prior to the conclusion of the Strategic Arms Reduction Treaty (START), that START would be "effective and viable only under conditions of compliance with" the ABM Treaty as signed on May 26, 1972. Soviet negotiators also made clear in a unilateral statement associated with START that "events related to withdrawal by one of the Parties" from the ABM Treaty could be grounds for exercising the right to withdraw from START. A similar condition was associated with the Russian Duma's consent to ratify START II. Russia eventually chose not to implement this threat with respect to START I, which continues in force, but did issue a statement, the day after the U.S. withdrawal from the ABM Treaty became effective, saying it considered itself free of the constraints of START II, which in any event had never entered into force (*see* Strategic Arms Reduction Treaty [START I]; Strategic Arms Reduction Treaty [START II]).

Problems Interpreting the ABM Treaty

Almost from the beginning, the necessarily vague diplomatic language of the ABM Treaty posed serious problems of interpretation. One controversy in particular arose in the mid-1980s, soon after President Ronald Reagan announced the intention of the United States to pursue robust missile defenses through a Strategic Defense Initiative (SDI). Some argued that although the treaty banned the deployment of sea-, air-, space-, and mobile land-based ABM systems, it did not prohibit research and development into ABM systems related to those areas. Advocates of this position, which came to be known as the "broad interpretation," further argued that the language of Agreed Statement D, referring to the potential creation in the future of ABM systems "based on other physical principles," allowed their development and testing but not their deployment. Others believed that the ABM Treaty prohibited the development and testing as well as the deployment of such exotic ABM systems. This position came to be known as the "narrow interpretation." The Reagan administration officially adopted the broad interpretation in 1985, and this eventually led to a confrontation with the U.S. Congress over which interpretation had been associated with the treaty during its ratification process and whether the executive branch had a right to reinterpret treaties once ratified. In 1992, President William Clinton's administration officially renounced the "broad interpretation" and reinstated the "narrow interpretation" as the official policy of the United States. Thereafter, it substantially reduced funding for research into missile defenses and dismantled existing missile defense research and development programs.

The U.S. Decision to Withdraw from the ABM Treaty

Upon assuming office in 2001, President George W. Bush announced that it was the policy of his administration to deploy effective missile defenses against the threat of limited attacks by a handful of missiles launched by rogue states, and to do so as soon as technically feasible. This set the United States on an inevitable collision course with the ABM Treaty. On December 13, 2001, President Bush gave formal notice to Russia that the United States was withdrawing from the ABM Treaty in accordance with the requirement contained in Article XV of the treaty to give six months advance notice. In making his announcement, the president noted that the world was vastly different from that which existed in 1972 when the treaty was signed, that one of the signatories, the Soviet Union, no longer existed, and neither did the hostilities that once characterized relations between the two countries. He cited the imperative of having the freedom and flexibility to develop effective defenses against ballistic missile attack by terrorists or hostile rogue states and the need to move beyond mutual assured destruction (MAD) as the basis of deterrence. This withdrawal became effective on June 13, 2002.

Although the Bush administration had held a series of intense discussions with Russia over the fate of the ABM Treaty, in which ideas for revising or modifying it were discussed as alternatives to withdrawing from the treaty, the Bush administration was increasingly convinced that a clean break with the past was in order. There were three principal reasons for this decision. First, the ABM Treaty was no longer an appropriate basis for the increasingly cooperative U.S.-Russian relationship. Second, deterrence based solely on mutual assured destruction, as institutionalized by the ABM Treaty, could no longer be considered necessary vis-à-vis Russia nor credible against likely adversaries. Deterrence needed to be reinforced by both offensive and defensive means. Third, the ABM Treaty presented an obstacle to those testing and development activities considered essential by the administration to finding the most effective and affordable means of defending against ballistic missiles of all ranges. Moreover, the ABM Treaty prohibited cooperation between the United States and its allies in developing missile defenses, an avenue the United States was determined to pursue through NATO as well as bilaterally with key friends and allies.

Russia reacted with moderation, given the dire warnings its leaders and diplomats had issued up to that time regarding the potentially negative effects that would surely accompany any U.S. effort to withdraw from or substantially modify the ABM Treaty. In a response given the same day as the U.S. withdrawal announcement, President Vladimir Putin said Russia believed the U.S. decision to be mistaken but asserted it would not pose a threat to the national security of Russia. He reaffirmed his commitment to improving U.S.-Russian relations and called on the United States to put into legally binding form the unilateral strategic offensive reductions that both he and President Bush had respectively announced a month earlier during a summit meeting in Washington and at President Bush's ranch in Crawford, Texas. In fact, the United States and Russia subsequently agreed to a legally binding treaty on further reductions in strategic offensive arms in May 2002, despite the U.S. announcement of its pending withdrawal from the ABM Treaty.

—Kerry Kartchner

See also: Arms Control; Standing Consultative Commission; Strategic Offensive Reductions Treaty

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ANTINUCLEAR MOVEMENT

Since the dawn of the nuclear age, the antinuclear movement has raised logistic, safety, environmental, moral, and other concerns about the use of nuclear technology for peaceful or military purposes. The movement's main policy goals, its size, and its perceived influence have varied over time, and its history can be divided into four main periods of activity. From 1944 to 1948, the movement consisted of elites who pushed for civilian control of nuclear technology and considered establishing international control of nuclear knowledge under the United Nations. From 1957 to 1963, the movement included the broader public and pushed for arms control, specifically focusing on limits on nuclear testing. From the late 1960s through 1980, the antinuclear movement worked with the emerging environmental movement to oppose the widespread use of nuclear power plants. And from 1979 through 1984, the movement was at its largest and most influential and was focused on the proposal for a U.S. and Soviet "nuclear freeze."

Distinct issues emerged in each of these four periods, but they all reflected changing views on two key questions: First, is it possible to get benefits from nuclear energy without encountering dangerous side effects such as the diversion of nuclear technology for military purposes or environmental damage? Second, is it possible to have arms control even when a nation fears its opponent's military strength? Across the four periods, the movement accumulated strength, even though most of its membership changed, because leaders and organizations involved in one issue often reemerged to provide leadership in later periods.

History and Background

Even as the first research and testing of nuclear weapons went forward, some of the scientists involved began to question the long-term implications of their work. These questions moved to a broader setting with the use of nuclear weapons at Hiroshima and Nagasaki. Within elite academic, political, and scientific circles, many expressed a mix of fear of the new weapons' power and hope that peaceful uses of nuclear energy might aid future development. There also was a general view that decisive action to establish control of the new technology was necessary, but there was less agreement on what action should be taken. The majority of the public, however, more focused on recovering from the end of a long war and keeping the postwar economy growing, expressed few worries about these issues.

Several leading scientists formed the Federation of Atomic Scientists in hopes of influencing debate. Because of the technical nature of the issues involved, the scientists' views were accorded great weight, but some politicians and military officials believed that the scientists were naive in their political objectives. Many of the scientists were pleased, though, when the 1946 Atomic Energy Act gave the civilian-led Atomic Energy Commission a near monopoly on control of peaceful and military U.S. nuclear programs (*see* Federation of American Scientists).

Debate then shifted to the idea of international control. This idea brought other groups, such as existing peace groups and world federalist organizations, into the antinuclear movement. Their hopes for real action on the Baruch Plan, the U.S.-backed initiative to give control of all nuclear weapons to the United Nations, were dashed by mounting Cold War tensions (*see* Baruch Plan). As fear of an emerging Soviet threat spread, support for any type of arms control or international action declined rapidly. Soon, those who continued to question U.S. government policies faced scrutiny by the Federal Bureau of Investigation and supporters of Senator Joseph McCarthy.

Although Cold War tensions played a major role in ending the first phase of antinuclear activity, they also contributed to activists staying focused on the issue and to the emergence of a second major phase of activity in the mid-1950s. By then, nuclear weapons technology had moved forward with the development of the hydrogen bomb and missile delivery systems, the defense budgets of both superpowers were increasing rapidly, and there was mounting global tension. Several new groups, notably Pugwash and the Committee for a Sane Nuclear Policy (SANE), were established to inform policymakers and the public on the dangers of nuclear escalation and possible flaws in deterrence strategies.

These new groups generated significant media and policymaker attention, but the mass public became more focused on issues related to nuclear testing. In 1954, radioactive fallout from a U.S. test on Bikini Island covered a Japanese fishing boat. There also were mounting reports that radioactive fallout would cause genetic defects and cancer. Quickly, polls showed widespread public support for a test ban, and existing antinuclear organizations began to push it as an important first step in arms control. Support for the test ban also came from religious figures, including Pope Pius XII, leaders in the nonaligned movement, such as Jawaharlal Nehru, and political parties from Japan to England. A small number of activists also used direct action, such as sailing boats close to test sites. It is difficult to say precisely how much influence these polls and various groups had, but it certainly was clear to both U.S. and Soviet leaders that they could win public opinion points by adopting moratoriums on testing and negotiating a test ban. In 1963, the Limited Test Ban Treaty, which banned testing in the atmosphere, under water, or in outer space, was signed. The treaty was a victory for the antinuclear movement, but now lacking a main issue around which to rally support, the movement again receded.

During the 1960s and 1970s, smaller groups of people continued to criticize the overall development of nuclear strategy, specific weapons systems, and missile defense systems. Many peace groups and other foreign policy–oriented groups shifted their focus to the Vietnam War. Another branch of the antinuclear movement began to work with environmental and local citizens groups to protest nuclear power plants. At first, these protests were small, but in time, four factors emerged that strengthened the movement. First, rising oil prices made nuclear energy a more attractive alternative. Second, the U.S. government radically reorganized its energy bureaucracy. Plans for the reorganization gave the movement an issue to focus on and, later, it had new entry points for lobbying. Third, both government and private research showed that the dangers of nuclear power had been understated. Fourth, several small accidents and near-accidents highlighted potential problems.

In their attempts to limit the spread of nuclear power, movement strategists first used legal action and demands for full environmental impact reports. By 1976, they had moved to an electoral strategy, placing several antinuclear referenda on ballots and supporting the Democratic Party's platform, which called for developing nonnuclear sources of energy. They then added tactics of direct action. For example, members of the Clamshell Alliance occupied the construction site of the Seabrook nuclear power plant in New Hampshire. These actions revitalized the old debate over whether the benefits of nuclear energy would outweigh the dangers. The movement was gradually gaining public support, although it lost a key referendum battle in California in 1976. Then, the debate was radically changed, settling in favor of opponents of nuclear power because of accidents at Three Mile Island, Pennsylvania, and Chernobyl, Ukraine (*see* Chernogyl; Three Mile Island).

Nuclear Freeze

By the late-1970s, many people in both the public and policymaking circles saw Cold War tensions, the dangers of nuclear war, and arms races that were only partially limited by arms control agreements as unpleasant but unavoidable facts of modern life. Randall Forsberg, a researcher trained at the Massachusetts Institute of Technology, disagreed. Forsberg argued that, as the first step toward international security, the United States and the Soviet Union needed to end the arms race by freezing the testing, production, and deployment of nuclear weapons. Forsberg took the idea to existing peace, religious, and antinuclear groups. By early 1980, an Ad Hoc Task Force for a Nuclear Freeze had been created. The idea captured the attention of peace activist Randy Kehler, who then led efforts to put a freeze referendum on the ballot in three western Massachusetts districts. The freeze referendum passed in all three districts and did well even in areas that supported Ronald Reagan for president.

The freeze's early popularity was striking. Ironically, the movement's later success and expansion into a national movement were due to the actions of one of its greatest opponents. Reagan and many of his top advisers, fearing a rising Soviet threat, spoke repeatedly of increasing U.S. defense spending, purging arms control supporters from the bureaucracy, negotiating only from a position of strength, and fighting and winning a nuclear war. These statements led many to conclude that Reagan was determined to confront the Soviet Union at all costs and that he was not serious about arms control. These people supported the freeze both as a bold policy alternative and as a symbolic sign of disapproval of Reagan's ideas. As the movement gained strength, Reagan and his supporters speculated that it was inspired by Communist forces. They also argued that a freeze would lock any Soviet superiority in place, potentially worsen the U.S. position if the Soviets cheated on the agreement, and weaken the position of U.S. arms control negotiators. Ironically, these administration arguments only served to further convince many that Reagan was exaggerating the Soviet threat and was unwilling to negotiate seriously.

The spread of the freeze movement was dramatic and reflected a combination of opposition to Reagan's policies, a general antinuclear mood in the country following the accident at Three Mile Island, and a widespread desire to achieve arms control objectives without increasing the Soviet threat. Freeze proposals were passed by dozens of town and city governments, by legislatures from Massachusetts to Oregon, and in eight statewide referenda votes in 1982. Polls consistently showed that over 70 percent of the public supported a freeze, although the numbers declined significantly if the question was worded to suggest that the freeze could lead to Soviet military superiority. In November 1982, a march in New York drew 750,000 people and an initiative signed by more than 2 million people was delivered to the United Nations.

The freeze idea also developed support in Congress. Congressional activity was ultimately a mixed blessing for the movement. Although the movement's concerns got attention in the halls of power and drew increased press attention, the movement's original organizers lost some authority. More important, once the freeze entered the legislative process, it became subject to political negotiation and compromises that were not supported by everyone in the grassroots movement. In 1982, the House of Representatives considered a freeze resolution, but it lost 204–202 in the key vote. The resolution was defeated largely by Republicans and southern Democrats who supported the administration's view that a freeze should come only after significant arms reductions were achieved. In 1983, following an election that brought many freeze supporters to office, debate began anew. The House passed a freeze resolution 278–149 following a complicated debate that stretched some forty hours. Dozens of amendments were proposed, and the final resolution included one that would terminate the freeze if no mutual arms control agreements were reached. Both supporters and detractors of the freeze claimed the wording as a victory. The final vote likely overstated actual support for a freeze, since many saw the vote as a way of prodding the administration to support arms control. The Republican-controlled Senate never formally voted on the freeze.

Proponents of the freeze remained active through the 1984 election, but the movement had begun to wane. Disputes over whether to use legislative or grassroots tactics, what final language would be acceptable, and whether the freeze would really lead to peace or only distract attention from other initiatives began to split the movement. Voters in 1984 seemed more interested in Reagan's economic policies than Walter Mondale's support for the freeze. Reagan also greatly affected the movement by restarting arms control negotiations and calling for a missile defense system that would arguably remove the need for a freeze and bring new security. Supporters of the freeze argued that these Reagan initiatives were spurred by public support for the freeze, claiming that they won the war even if they lost the battle.

—*John W. Dietrich*

See also: Nuclear Weapons Free Zones

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ANTI-SATELLITE (ASAT) WEAPONS

Anti-satellite (ASAT) weapons are designed to attack satellites in orbit. Potential destruction and disruption mechanisms for ASAT weapons include nuclear warheads, high explosives, directed energy, kinetic energy, and electronic warfare.

The United States became concerned about countering the potential for nuclear weapons delivery systems in orbit soon after the beginning of the space age. It first tested an air-launched ASAT weapon from a B-47 bomber under the U.S. Air Force's Bold Orion program in 1959, and in the early 1960s the U.S. Navy tested systems launched by F-4 fighters. All of these earliest ASAT systems would have used nuclear warheads as the kill mechanism, but none of them became operational. In the early 1960s, Secretary of Defense Robert S. McNamara authorized development and deployment of limited numbers of two ground-based, nuclear-tipped ASAT systems. The army's Program 505 system used a Nike-Zeus launcher to conduct seven tests from Kwajalein Island in the Pacific between 1964 and 1966. Program 437, the U.S. Air Force system, used a Thor booster from Johnson Island and was tested sixteen times from 1964 to 1970. The indiscriminate nuclear kill mechanism on these systems could have destroyed or disabled all satellites in low-Earth orbit by pumping up radiation belts.

Both the Soviet Union and the United States began work on more discriminating ASAT systems during the 1960s. The Soviets developed a radar and optical guided co-orbital system with a high-explosive warhead that was launched from a Tsyklon-2 (SL-11) booster and tested it at least twenty times between 1968 and 1982. U.S. efforts during this period culminated in the successful September 13, 1985, test of the Miniature Homing Vehicle (MHV), a direct-ascent kinetic kill ASAT launched from an F-15 fighter.

Some analysts argued that these systems undermined strategic stability, and they were quite controversial in the United States. Congressional restrictions on testing led the administration of President Ronald Reagan to cancel the MHV system in 1988. The superpowers also attempted to address ASAT issues through formal arms control efforts, holding three rounds of dedicated ASAT negotiations in 1978–1979 and discussing the issue in the Defense and Space Talks from 1985 to 1991. None of these negotiations produced an agreement, an illustration of the considerable challenges surrounding efforts to control ASAT capabilities.

There has been no testing of dedicated ASAT systems by any nation since the 1980s, and there are no operational systems deployed today. There is, however, a large amount of residual ASAT capability worldwide, including nuclear-tipped ballistic missiles and ballistic missile defense systems, ground- and air-based lasers, and a wide range of electronic capabilities to spoof, disrupt, degrade, or destroy satellites.

—Peter Hays

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ARMS CONTROL

Arms control is any tacit or explicit agreement among states aimed at reducing the likelihood of war, the costs of preparing for war, or the damage should war occur. Arms control agreements seek to achieve these goals by restricting or reducing the numbers of military weapons or by placing limits on their operation. They may include a variety of verification and transparency measures such as on-site inspections, reciprocal exhibitions of military hardware, notifications, joint exercises, and data exchanges. Arms control encompasses both formal and informal means of agreement. As the focus of

Arms control in practice: negotiators from the United States, Japan, China, North Korea, South Korea, and Russia begin talks on the North Korean nuclear crisis in Beijing, February 2004. (Greg Baker/Pool/Corbis)

arms control efforts increasingly shifts to combating the proliferation of weapons of mass destruction and other types of weapons, recent arms control arrangements have come to include agreements among supplier states to limit the export of certain categories of weapons or materials that have military application, such as missiles, conventional arms, land mines, and chemical weapon precursor ingredients. For this reason, a recent textbook offered a very broad definition of arms control as "any agreement among states to regulate some aspect of their military capability or potential" (Larsen, p. 1). Unilateral measures, undertaken with a view to influencing the military force policies of another state, also may be considered a form of arms control.

Arms control is a relatively modern concept and must be distinguished from "disarmament," which refers specifically to a reduction in weapons. Arms control may include a mutual freeze in levels of armaments, an agreed-upon reduction, or even a controlled increase in certain areas of weapons (such as those considered more "stabilizing" or "verifiable" than others). It may also include provisions for controlling how subject weapon systems are operated, or even where they are based.

The modern concept of arms control arose in the late 1950s and early 1960s as a response to the onset of an increasingly intense and strictly bipolar nuclear competition between the United States and the Soviet Union. Its basic tenets were originally formulated by mathematicians and game theorists seeking to resolve the instabilities inherent in the dynamic interplay between the fear of nuclear surprise attack and the buildup of nuclear weapons stockpiles. The arms race then emerging between the two superpowers, which many feared would spiral out of control without some concerted effort to check it, provided the incentive and urgency for exploring diplomatic and political means of slowing, stopping, or eventually reversing the U.S.-Soviet competition in nuclear weapons. Arms control theory arose out of these concerns. It postulated that given the means to independently verify military capabilities through newly developed satellite technology, the two nations should be able to surmount the distrust that had given rise to the Cold War through the implementation and mutual verification of incremental arms control arrangements. In theory, these incremental arrangements, initially very modest, would in turn engender sufficient trust to proceed toward more complete arms control agreements, and eventually toward a process of actual disarmament.

The "build-down" concept developed in the 1980s was a variation of this theory. This concept was conceived near the height of the U.S.-Soviet arms race when both sides were building scores of new nuclear warheads each year. The idea would have involved a series of reciprocal reductions in U.S. and Soviet strategic nuclear warheads whereby three or more older warheads would have been withdrawn and dismantled for every new warhead introduced into the respective arsenals of the two nations, thereby gradually enforcing a drawdown. Eventually, the two sides simply agreed to radical cuts in strategic nuclear missiles and warheads.

Arms Control Objectives

These early theoretical explorations of the possibilities for arms control identified three fundamental objectives: to reduce the likelihood of war by creating and reinforcing a stable structure of international arms control agreements; to reduce the costs of preparing for war by providing for equivalent levels of security at lower quantities of armaments; and, by laying the basis for smaller armed forces, to limit the damage should war nevertheless occur.

With these ends in mind, the early theorists of modern arms control developed a coherent series of principles to guide negotiators and policymakers in approaching arms control as a process. These principles may be summarized as follows:

- Arms control "was not an end in itself but a means to an end and that end was first and foremost the enhancement of security, especially security against nuclear war" (Bull, p. xx).
- The superpowers shared a common interest in avoiding nuclear war, and that common interest could and should be the basis for effective arms control agreements.
- Arms control was an adjunct of national security, and not the other way around. Arms control and a nation's national security strategy should work together to promote national objectives. Were they to work at cross-purposes, the legitimacy of one or the other would necessarily suffer.
- Arms control encompassed more than the conclusion of formally negotiated agreements. It could include informal arrangements and unilateral confidence-building measures.

Originally, the concept of arms control, while designed to promote stability, was neutral with regard to the form of that stability. However, as the interaction of offensive and defensive strategic nuclear technology gave way in the mid- to late 1960s to the rise of offensive-dominant approaches to deterrence, and deterrence itself came to be defined narrowly as threatening a massive retaliation, eventually it became assumed that the main objective of arms control was to stabilize the situation of mutual assured destruction between the superpowers (*see* Massive Retaliation; Mutual Assured Destruction). Thus the operational objectives of arms control came to focus on stabilizing and perpetuating a condition of mutual deterrence by prohibiting new technology that threatened to increase the vulnerability of either side's offensive retaliatory forces. This thinking eventually led to the conclusion of the Anti-Ballistic Missile Treaty of 1972, which severely restricted the deployment of ballistic missile defenses (*see* Anti-Ballistic Missile [ABM] Treaty).

Determining Success or Failure

Ever since the rise of classical arms control theory and its application in national security policy, there has been an intense debate over the prospects and necessary conditions for the success or failure of arms control measures. On the one hand, the pro–arms control community has largely focused on the intangible benefits allegedly accruing from the process of negotiation, which include greater mutual understanding, a deliberate shift to more stable avenues of competition, a lessening of political tension, and improvements in the "learning curve" each nation experiences with regard to its security policies and structures. This school of thought has generally assumed that arms control could transcend political tensions among prospective arms control partners and could be used as an instrument to ameliorate those tensions. The successful negotiation of increasingly ambitious arms control arrangements by more and more states on both a bilateral and multilateral basis is taken as evidence of the benefits of this approach.

On the other hand, those skeptical of arms control have focused on the allegedly poor track record of tangible arms control results, the modest negotiated outcomes of arms control processes, and their impact on other national security objectives. They have also taken issue with the very assumptions of arms control theory, arguing that arms control has emphasized the inherently futile task of finding technical solutions to essentially political problems. For example, many skeptics have held that arms control theory and practice pay too little attention to problems of verification and compliance. The essential verification problem has been the limited ability of surveillance technology to fully and adequately monitor the activities of a treaty party determined to find ways to cheat. The compliance problem consists of the reluctance of some states to act on unavoidably ambiguous evidence of cheating, where standards of evidence are set unrealistically high, out of concern that raising such issues would itself complicate the prospects for further progress in the arms control process. These two problems are, according to the critics of arms control, compounded by the asymmetries between an open and basically law-abiding Western culture and those closed, controlled, and distrusting governments bent on exploiting advantages to be gained by cheating on assumed international obligations.

Skeptics of arms control during the Cold War further held that arms control theory exaggerated the extent to which a mutual interest in avoiding nuclear war could serve as a sound basis for effective arms control, overestimated the extent to which arms control agreements could curb allegedly destabilizing technologies, and underestimated the extent to which the arms control process itself could be insulated from the overall politics of the U.S.-Soviet relationship. Critics also alleged that, too often, arms control became an end in itself, divorced from or out of synch with larger national security objectives, in contradiction to the original tenets of classical arms control theory.

Nevertheless, arms control evolved into a legitimate instrument of national security and an important forum for international conflict management. Early bilateral U.S.-Soviet efforts were soon complemented by a series of multilateral arms control efforts, many under the auspices of the United Nations, others as ad hoc arrangements among groups of nations. Beginning with the 1968 multilateral Nuclear Nonproliferation Treaty, several international arms control agreements emerged in the 1970s, 1980s, and early 1990s. These arms control efforts involved, for example, arrangements for nuclear weapons free zones, constraints on specific weapon systems, agreements on measures designed to promote transparency and confidence-building among states, and nuclear testing constraints. Another series of multilateral arms control agreements have been directed at limiting and reducing the proliferation of conventional weapons and ballistic missile technology. See Table A-1 for a more comprehensive list of existing international arms control regimes.

The Process of Arms Control Negotiations

With regard to the mechanics of negotiating an arms control agreement, it has been traditional for delegations from the prospective parties to meet on neutral ground. For this reason, Geneva, Switzerland, has been a favored location. Once draft treaty text has been agreed to, a "summit" meeting is held between the heads of state of the various parties (so called because this is the highest possible level of meeting between representatives of states) and copies of the actual text in all relevant languages are signed. It also is common for modern arms control agreements to incorporate annual reviews of compliance as one of their obligations. Most review conferences take place in Geneva, but Vienna, Austria, also has become home to several key arms control implementation bodies, such as the International Atomic Energy Agency, which has responsibility for overseeing compliance with the Nuclear Nonproliferation Treaty.

Arms Control after the Cold War

Arms control, like many other aspects of national security, has been subject to considerable rethinking in the aftermath of the collapse of the Soviet empire. For some, the end of the bilateral U.S.-Soviet competition has meant that arms control has lost its primary relevance, that the new era of American preeminence requires that the United States free itself from as many arms control "constraints" as possible, and that legally binding treaties incorporating complex verification measures have outlived their usefulness. For others, the end of the Cold War has meant a realignment of the arms control agenda but not diminishment of arms control as an instrument of national strategy. Most agree that the new focus of arms control must be on combating the proliferation of

Table A-1: Examples of Arms Control Regimes

Nuclear Weapons Free Zones	Weapons Systems Constraints	Confidence-Building Measures	Nuclear Testing Constraints	Suppliers Club & Export Controls
• Outer Space Treaty	• ABM Treaty	• Hot Line	ˆ Limited Test Ban Treaty	• Non-Proliferation Treaty (NPT) & Zangger Committee
• Seabed Treaty	• INF Treaty	• Accidents Measures Agreement	• Threshold Test Ban Treaty (TTBT)	• Australia Group
• Africa NWFZ	• START I Treaty	• Confidence- and Security-Building Measures (CSBMs)	• Peaceful Nuclear Explosions Agreement	• Missile Technology Control Regime (MTCR)
• Treaty of Tlatelolco [Latin America & Caribbean NWFZ]	• START II Treaty	• Open Skies	• Comprehensive Test Ban Treaty (CTBT)	• Fissile Material Cut-Off Treaty (FMCT)
• South Pacific NWFZ	• Biological and Chemical Wpns Conventions	• ICBM & SLBM Launch Notifications		
	• SORT Treaty	• De-targeting Agreement		

weapons of mass destruction through a new focus on multilateral mechanisms. Securing residual nuclear stockpiles in Russia and the United States, as well as in other countries, also has loomed large on the post–Cold War security agenda, and several new policy initiatives address these concerns. These initiatives, such as the Nunn-Lugar Program and the Cooperative Threat Reduction Program, fall outside the traditional definition of arms control. Yet their objectives correspond with the fundamental objectives of classic arms control theory—that is, they consist of cooperative efforts to reduce the threat of war; to promote stability, transparency, and predictability; and to limit the damage should war occur. Other multilateral nonproliferation efforts also enlarge the definition of arms control because they are not based on legally binding or formal treaties but instead involve nonbinding "supplier groups," or groups of nations that have formed voluntary associations to restrict international trade in weapon systems deemed destabilizing. Such is the case, for example, with the Missile Technology Control Regime, which includes more than thirty countries agreeing to restrict the international transfer of missiles and missile technology.

Arms control, then, in its broadest sense, is likely to remain a critical component of international stability and national strategy, even as the forms it takes may evolve to meet the changing and dynamic requirements of the international system.

—Kerry Kartchner

See also: Détente; Disarmament; Entry into Force; Implementation; Verification

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ARMS CONTROL AND DISARMAMENT AGENCY (ACDA)

The Arms Control and Disarmament Agency (ACDA) served as the lead U.S. government agency for dealing with arms control issues for nearly forty years. It was legally established by President John F. Kennedy on September 26, 1961, in response to congressional and presidential views that a strong institutional advocate for arms control was needed to integrate arms control considerations into U.S. defense and foreign policy. ACDA was juxtaposed between the weapons-centric mandate of the U.S. Department of Defense and the "desk officer" mentality of the U.S. Department of State.

Until its merger into the Department of State in April 1999, ACDA was responsible for formulating and implementing arms control and disarmament policies that promoted the national security of the United States and its relations with other countries. In carrying out these responsibilities, ACDA prepared and participated in discussions and negotiations with foreign countries on such issues as strategic arms limitations, conventional force reductions in Europe, protocols for preventing the spread of nuclear weapons to countries that did not possess them, chemical weapons prohibitions, and international arms trade regulations. The main functions of the agency were to prepare for and manage U.S. participation in negotiations on arms control and disarmament, to conduct and coordinate arms control research, to ensure that the United States could verify compliance with existing agreements, and to disseminate information on arms control and disarmament to the public.

The agency took the lead in framing U.S. options and providing staff support for the Chemical Weapons Convention (CWC) negotiations, performed an important watchdog role in the nuclear nonproliferation field, and took a policy lead in designing improved safeguards to strengthen nuclear nonproliferation. ACDA promoted the utilization of confidence-building measures in regions of tension, particularly on the Korean peninsula, to address the demand side of proliferation problems.

In 1993, support for maintaining the agency began to wane. In 1996, Senator Jesse Helms, chairman of the Senate Foreign Relations Committee, demanded the William Clinton administration's acquiescence in his goal to merge the independent foreign affairs agencies into the State Department as the price for ratifying the Chemical Weapons Convention. Pursuant to the Foreign Affairs Reform and Restructuring Act of 1998, an undersecretary of state for arms control and international security was created within the State Department. This undersecretary took on duties previously handled by personnel of the former State Department Bureau of Political-Military Affairs and ACDA, effective April 1, 1999. In many ways, ACDA was a victim of its own success, having effectively integrated arms control considerations into the fabric of U.S. foreign and defense policymaking.

—*Kerry Kartchner*

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ARMS RACE

The concept of a nuclear arms race was the subject of considerable debate during the Cold War era. Many observers expressed concern about whether the rivalry between the superpowers would inevitably result in a global nuclear war, with its accompanying devastation, or lead to a stable strategic relationship where the necessary conditions to avoid such a calamity could be maintained. More recently, concern about nascent arms races have spread to regional rivalries. India and Pakistan, which have both undertaken a series of nuclear tests and remain at loggerheads over Kashmir, appear to be locked in an arms race, for example, and many analysts predict that the problem will worsen as other countries develop new weapons of their own.

The term "arms race" is highly debated. Some thinkers choose to dismiss the concept, while others identify it as one of the principal causes of war. The term itself suggests a degree of folly or mutual hysteria between two or more states whereby they find themselves "trapped" in a competition to build larger or more destructive arsenals. True arms races, which are animated by an action-reaction dynamic, are relatively rare. Notable examples, however, include the Anglo-German naval race before World War I and the race between the United States and the Soviet Union to develop intercontinental ballistic missiles (ICBMs) during the 1950s. Nuclear weapons have highlighted the potential costs such races can have if they lead to catastrophic war.

The acquisition of arms is a normal part of state behavior. States acquire arms as part of their duty to help preserve the state and protect their citizens. Individual states do not exist in a vacuum, however. A national decision to increase the size or capability of an arsenal prompts other states to counter any increase in capability. The "security dilemma" (that is, actions taken to increase one's security tend to decrease the security of others) precludes leaders from taking at face value reassurances that their competitors' military programs are only being undertaken for defensive purposes. The security dilemma sometimes produces an action-reaction cycle that may lead to competitive arms races as states seek to gain advantages over their neighbors. After China tested a nuclear weapon in the 1960s, for example, Indian officials felt compelled to develop and test their own nuclear capability, which eventually led to a decision by Pakistani officials to also field a nuclear arsenal.

The term also implies a deviation from the norm of military modernization. Colin Gray has identified four criteria that must be present to produce an arms race (an action-reaction competition): (1) there must be two or more parties that are deliberate rivals; (2) the parties must structure their armed forces to improve the probable effectiveness of the forces in combat with, or as a deterrent to, the other arms-race participants; (3) they must compete in terms of the quantity or quality of their arsenals; and (4) there must be rapid increases in either the quantity or quality of competing arsenals beyond normal evolutionary improvements in force structure (Gray, p. 40).

Real danger from such arms races arises when one state gains a temporary advantage and sees its opponent's armaments program as a threat to this advantage, which leads to pressures to take preventive or preemptive action (for example, the Israel strike on Iraq's Osirak nuclear reactor in 1981). States also may act when an arms race is seen as threatening a general military equilibrium. These dangers are exacerbated by the secrecy that surrounds all types of military activities, especially the procurement and testing of new military hardware. Decisions are invariably based on incomplete information and often rely on worst-case assumptions about a potential opponent's intentions and capabilities.

A balanced strategic relationship may develop when neither side has an advantage and sees no way of gaining one. Here, nuclear weapons may be the ultimate guarantee of arms-race stability: Both parties ensure the devastation of the other—in a phenomenon known as "mutual assured destruction"—even if their conventional capabilities are unbalanced.

Since arms races are about relative military power, they can be volatile. Developments in military technology, such as the advent of nuclear weapons or long-range delivery systems, can alter the relative balance between offensive and defensive capabilities. For example, World War I often is cited as an instance when defensive technologies had the advantage, leaving millions to die in the trenches for relatively little gain.

The term "arms race" also is used in a less technical sense simply to describe the nuclear arms race that ensued following the first use of an atomic weapon against Hiroshima on August 6, 1945. Successive military development, such as Soviet acquisition of nuclear weapons, the development of the hydrogen bomb, the development of ballistic missiles, the deployment of multiple independently targetable reentry vehicles, and the advent of missile defenses, thus constitutes an "arms race." Although scholars suggest that Soviet and U.S. planners and scientists often marched to their own drum—weapons developments did not always follow an action-reaction pattern—popular discourse uses the term "arms race" to describe the balance of terror at the heart of superpower relations during the Cold War.

In the aftermath of the Cold War, a new international dynamic is producing a new type of arms race. As so-called "rogue states" seek nuclear, chemical, or biological weapons, an arms race is emerging between those who want to develop such a capability and those who wish to prevent them from doing so—either by restricting access to the relevant technology or by developing appropriate defenses (for example, ballistic missile defenses). The latter represents the classic competition between offense and defense, an action-reaction dynamic that lies at the heart of the notion of an arms race.

—Andrew M. Dorman and James J. Wirtz

See also: Cold War; Russian Nuclear Forces and Doctrine

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ARMS RACE STABILITY

See Arms Race

ASSURED DESTRUCTION

The term "assured destruction" is often used interchangeably with the term "unacceptable damage." Secretary of State Robert S. McNamara in 1967 defined assured destruction as "an ability to inflict at all times and under all foreseeable conditions an unacceptable degree of damage upon any single aggressor or combination of aggressors—even after absorbing a surprise attack." During the Cold War era, U.S. strategic nuclear forces were assessed, in part, in terms of their assured-destruction capabilities, that is, the amount and type of damage they could inflict on an enemy in a retaliatory strike. The other measure of military readiness—damage limitation—described the degree to which U.S. forces were capable of reducing the damage that an enemy could inflict on U.S. forces, territory, and population.

In the mid-1960s, McNamara dropped the damage-limitation criterion, and assured destruction became the principal measure of the adequacy of the posture, size, and composition of U.S. strategic nuclear forces. Eventually, assured destruction came to describe the dominant theory of deterrence underlying U.S. declaratory strategic doctrine and arms control policy. According to this theory, it was necessary for the sake of deterrence that U.S. and Soviet societies remain vulnerable to nuclear destruction by the other side. It therefore was necessary to avoid endangering the enemy's own strategic forces and assured-destruction capability, which meant avoiding counterforce, first strike–type forces, or even giving one's own forces sufficient accuracy to threaten the other side's forces. Also according to this theory, the notion of strategic superiority was dismissed because once one or both sides achieved sufficient nuclear power to assure the total societal destruction of the other, any additional amount of nuclear force would be irrelevant.

U.S. nuclear strategy has incorporated some form of assured-destruction targeting since McNamara's era, but the designated targets covered by this concept have evolved considerably. McNamara originally defined assured destruction as the ability to destroy one-third of the Soviet population and two-thirds of its industry. These figures were derived not from any assessment of what actually deterred the Soviet Union but from the physics of nuclear strikes against a widely dispersed population. Pentagon analysts in the 1960s believed that it would take nuclear weapons representing the equivalent of approximately 400 megatons to destroy 30 percent of the Soviet population and about 50 percent of its industrial capacity, and that this level represented the point of diminishing returns. That is, using more and more weapons did not produce appreciably more damage. The figure of 400 equivalent megatons (EMTs) then became the canonical measurement of an adequate "assured destruction" capability, symbolizing the minimum amount of nuclear force needed for the United States to be able to unleash "unacceptable" damage on the aggressor after surviving a first strike.

Over the following years, the Pentagon successively reduced the percentage of Soviet population and industry they believed should be held at risk for assured-destruction purposes. Nevertheless, later administrations retained the assured-destruction targeting mission but moved away from defining it in terms of population and industry. Under President Richard Nixon, for example, the operational definition of assured destruction was revised to focus on Soviet economic recovery capabilities rather than pure urban industrial targets. Military planning under this approach consisted of more limited, flexible targeting options. Under President Jimmy Carter, the assured-destruction mission was further revised to include strikes limited to Soviet leadership and the war-supporting industry. By the end of the first Ronald Reagan administration, assured destruction had come to describe the mission assigned only to those nuclear forces that would be held in reserve from the initial phases of a conflict. In other words, the assured-destruction mission represented the types of attacks that would be initiated only if all else had failed, as a last resort. Even then, the actual targeting strategy no longer focused on deliberate strikes against urban industrial and population targets but on targets more relevant to the actual military objectives of the overall war plans. Thus, the concept of what represented "unacceptable damage" or having an "assured-destruction capability" has been a more or less subjective assessment that has evolved considerably over the years in keeping with the evolution of U.S.-Russian relations.

—Kerry Kartchner

See also: Deterrence; First Strike; Mutual Assured Destruction

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ATOMIC BOMB

See Fission Weapons

ATOMIC ENERGY ACT

The Atomic Energy Act, which was originally enacted in 1946 and significantly modified in 1954, lays out the government structure for control of atomic energy in the United States and the core legal framework governing the spread of information on atomic energy. The 1946 act was submitted by Senator Brien McMahon (D–CT) and is thus sometimes referred to as the McMahon Act. It sought to keep a U.S. monopoly on atomic technology by banning most kinds of international cooperation. Within the United States, the government was given complete ownership of all fissile materials, of the facilities for producing them, and of restricted patents for research funded by the government. The act resolved the crucial question of military versus civilian governmental control by establishing the Atomic Energy Commission (AEC), led by five civilians, and giving the AEC oversight of all weapons work as well as civilian usage. To balance this new executive-branch commission, the act also created the congressional Joint Committee on Atomic Energy (JCAE) and gave it jurisdiction over all bills related to atomic energy and oversight of AEC activities (*see* Atomic Energy Commission).

In 1954, three significant changes were made. Restrictions on sharing weapons information with other countries were reduced in response to the need for an allied Cold War defense. Limits on the international exchange of other types of information were lowered in line with President Dwight D. Eisenhower's Atoms for Peace initiative (*see* Atoms for Peace). Crucially, the government monopoly of ownership was broken to allow for the development of a private atomic-power industry.

To regulate atomic information, the 1946 act also created the category of "restricted data," defined to include any information on the manufacture or utilization of fissile material. It then greatly limited the dissemination of such information. In essence, all atomic energy information was controlled, or "born secret," unless the government released the information. In time, critics argued that this policy was slowing research, costing the government millions of dollars in security precautions, and fueling popular distrust of a government that refused to release data on events such as atomic tests conducted on civilians.

—John W. Dietrich

See also: Nuclear Regulatory Commission

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ATOMIC ENERGY COMMISSION

The Atomic Energy Commission (AEC), created in 1946 by the Atomic Energy Act, oversaw all development and uses of atomic energy and controlled the flow of information about atomic energy under the act's restrictive terms (*see* Atomic Energy Act). Its responsibilities were modified over time, and the AEC was dissolved in 1974. Its creation was shaped by post-Hiroshima debates over whether control of atomic energy should rest in military or civilian hands and on how to develop the peaceful uses of atomic energy. The AEC was led by a commission of five civilians appointed by the president. It had four operating divisions, including one for military applications, and had a Military Liaison Committee of six senior officers. Beyond weapons work, the AEC controlled all fissile materials, all facilities used in their production, and much of the research conducted in the field. In Congress, because jurisdiction over these issues was given to the special Joint Committee on Atomic Energy (JCAE), an unusually tight relationship developed between the executive agency and congressional officials influential in AEC oversight and appropriations.

In 1954, the Atomic Energy Act was revised to allow for the development of a private atomic-power industry. This gave the AEC a new regulatory role. Critics charged, though, that this new role created conflicts of interest because the AEC was subsidizing research and facilities in the same industry that it was overseeing. AEC officials also had an institutional interest in promoting the development of the atomic industry and often relied on information supplied by that industry. These problems were heightened by the tight secrecy that enveloped all atomic policy and by the degree of technical knowledge necessary to understand it. Few people outside of the AEC and JCAE were able to challenge regulatory decisions. Rising concerns that the AEC was overly restricting and suppressing potentially damaging information on atomic safety and other issues, along with a view that it had oversold the usefulness of its product, led to the AEC's dissolution. Its responsibilities were transferred to the Energy Research and Development Administration, which later shifted control to the U.S. Department of Energy and the Nuclear Regulatory Commission.

—John W. Dietrich

See also: Nuclear Regulatory Commission

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ATOMIC MASS/NUMBER/WEIGHT

Atomic number is the number of protons present in the nucleus of an atom and is usually indicated by the symbol Z. The atomic mass number is the sum of the number of protons and neutrons in the nucleus of an atom and is usually denoted by the symbol A.

Atomic weight is the mass of an atom compared to the mass of the carbon 12 atom, which is defined, by international agreement, as having a mass of exactly 12.00000. Atomic weight usually refers to the average atomic weight of a given element with all its naturally occurring isotopes.

Atomic weight is sometimes referred to as atomic mass. Where atomic weight refers to the average atomic weight of an element, atomic mass is the term typically used to describe the weight of an individual isotope.

J. L. Proust in 1797 and John Dalton in the early 1800s both performed initial work with atomic weights. Proust theorized the law of definite proportions that states that the ratio of the weights of elements that make up a compound is constant. Dalton hypothesized that atoms of the same elements have the same atomic weight and that atoms of different elements have different atomic weights. He also created a scale of atomic weight based on hydrogen, which he set equal to 1. This early work with atomic weight eventually led to more accurate methods of measuring the atomic weight of elements and ultimately to D. I. Mendeleyev's 1869 table of elements arranged according to atomic weight.

The atomic mass number of an atom is equal to the atomic number (that is, the number of protons) plus the number of neutrons, usually denoted by the symbol N. Therefore, the equation for atomic mass is:

$$A = Z + N$$

As an example, the isotope uranium 235 has 92 protons and 143 neutrons. In this example, the atomic number is 92 and the atomic mass number is 235. Uranium 238 has 92 protons and 146 neutrons. In this example, the atomic number is 92 and the atomic mass number is 238. Therefore, different isotopes of the same element have the same atomic number but different atomic mass numbers based on the number of neutrons present in the nucleus.

Because atomic weight is defined as the mass of an atom relative to the mass of another atom, it is essentially the ratio of two masses and therefore unitless. However, the atomic mass unit, abbreviated "amu," has been defined as exactly one-twelfth of the mass of the carbon 12 atom. With this definition of the atomic mass unit, carbon 12 is equal to 12 amu, and all other atoms may be expressed in terms of atomic mass units relative to the carbon 12 standard.

Following the example above, the atomic mass for uranium 235 is approximately 235.0439 amu and the atomic mass for uranium 238 is approximately 238.0508 amu. The average atomic weight of uranium is 238.03 amu, because natural uranium is approximately 99.3 percent uranium 238 and 0.7 percent uranium 235.

—Don Gillich

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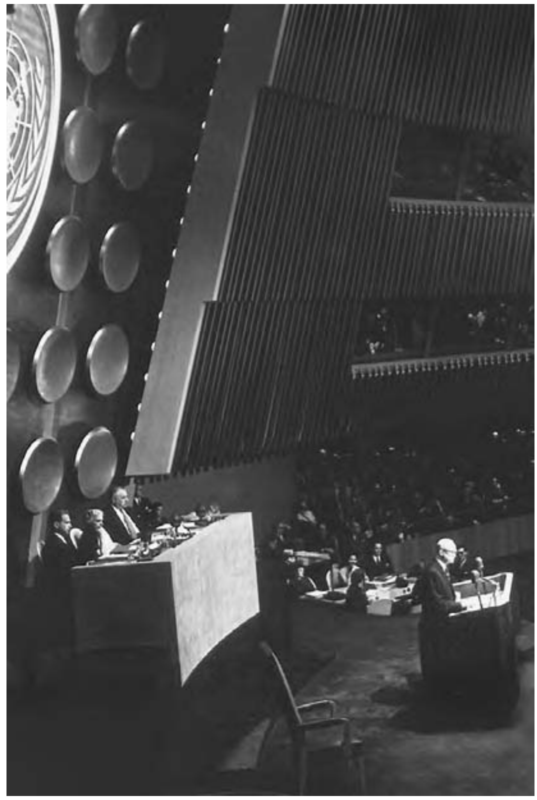
ATOMS FOR PEACE

In 1953, President Dwight D. Eisenhower addressed the General Assembly of the United Nations proposing an "Atoms for Peace" program that would establish an international agency to promote the peaceful uses of atomic energy. To achieve this objective, the agency would allow some sharing of nuclear materials while instituting safeguards to ensure that the materials would not be diverted to military applications. The new policy represented a compromise between promising access to nuclear technology and restricting access to it. It led to the founding of the International Atomic Energy Agency (IAEA) in 1957, which remains the most visible organ of nuclear nonproliferation. The IAEA is an autonomous agency representing 128 member states and is operated by an international staff (*see* International Atomic Energy Agency).



President Dwight D. Eisenhower delivers his "Atoms for Peace" speech to the United Nations, 1953. (Corel Corp.)

Prior to 1953, U.S. policy under the Atomic Energy Act was to maintain nuclear secrecy to preserve a nuclear monopoly. As more nations acquired nuclear weapons capabilities, however (the Soviet Union and the United Kingdom, in particular, had tested nuclear explosives, and others were pursuing civil nuclear programs), the policy was revised so that the United States could participate in the global market for emerging commercial applications of nuclear technology.

Originally, the Atoms for Peace program was envisioned to have an international agency that would serve as a depository for excess nuclear materials that, in turn, could be shared with nonnuclear nations for peaceful purposes. This would serve to limit the stockpiles of nuclear countries while allowing nonnuclear nations the peaceful benefits of nuclear technology and materials, which would ideally encourage them to not seek a nuclear program of their own. Meanwhile, the application of safeguards on all shared materials would control the spread of materials to military programs.

The IAEA was assigned two specific tasks. First, it was intended to make technical and safety advancements available to member states and to join with organizations in identifying and promoting innovative applications. Second, the IAEA was supposed to administer an international safeguards system to control nuclear bilateral and multilateral exports.

By 1962, the Atoms for Peace program had supplied twenty-six nations with training, research reactors, and fissile materials. Critics, however, claimed that the program was responsible for actually spreading rather than restricting nuclear weapons technology, charging that its members took a casual approach toward safeguards. However, the establishment of the IAEA allowed for the implementation of the Nuclear Nonproliferation Treaty (NPT) following its signing in 1968. The tension between protecting national interests by restricting access to nuclear technology and materials and promoting their use for peaceful purposes could be difficult to navigate. This was a problem that had to be recognized before the NPT could be finalized. For states without a nuclear weapons program, the novel technology was desirable because of its purported economic and social advantages. Compromise was essential, however, if nuclear materials were to be controlled while the technology spread. This tension remains an essential piece of the structure of the nuclear nonproliferation regime in place today.

—Jennifer Hunt Morstein

See also: Nuclear Nonproliferation Treaty; Nuclear Weapons States

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B

BACKFIRE BOMBER

See Bombers, Russian and Chinese Nuclear-Capable

BACKPACK NUCLEAR WEAPONS

Small, backpack nuclear weapons, also known as "man-portable nuclear weapons" or "special atomic demolition munitions," were developed during the Cold War and have become a matter of concern in recent years because of the danger of their use in a terrorist attack. With the miniaturization of nuclear devices in the late 1960s, the United States and the Soviet Union developed atomic mines that were man-portable. Some were so small (0.1 kiloton) that they fit into a backpack weighing only about 60 pounds. Others were designed for demolition work by combat engineers. The latter were carried in pieces by teams and could weigh in the hundreds of pounds, with an explosive yield of about 100 kilotons.

Although knowledge of Soviet weapons is limited, the man-portable devices were probably scheduled for use by Spetsnaz commando teams and KGB sabotage units against command and control installations, headquarters, and other high-value targets. They had a small nuclear core with a yield of about 10 kilotons. U.S. weapons were deployed with Special Forces units and engineer companies focusing on demolition work. Atomic mines or special demolition munitions were designed to create barriers to Soviet conventional force advances into Western Europe.

Suitcase nuclear devices became a matter of public concern after the Cold War when in 1997 Alexander Lebed, a retired Russian general and presidential hopeful, claimed that Russia could not account for 100 man-portable weapons. If they fell into terrorist hands, these weapons could be used to cause catastrophic damage. Other Russian and U.S. stockpiles of man-portable devices were eliminated in the early1990s.

—Gilles Van Nederveen

See also: Russian Nuclear Weapons and Doctrine; Tactical Nuclear Weapons

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BALANCE OF TERROR

The concept of the "balance of terror" was predicated during the Cold War upon the idea that a stable deterrent relationship would result if both superpowers could inflict unsustainable destruction upon the other. In other words, the threat of mutually assured destruction would cause both sides to be cautious in their interaction, and thus a stable strategic relationship would emerge.

It was originally thought that deterrence depended upon the West's monopoly of the control of nuclear weapons. Even after the Soviet Union conducted its first test of a nuclear weapon in 1949, many political and military leaders in the West thought that the preponderance of U.S. nuclear forces, along with the geographical advantages of the United States and U.S. technological leadership, would keep any Soviet expansionist tendencies in check. Peace would not, therefore, benefit from a "balance of terror," because the West did not need to be deterred. However, developments in Soviet nuclear forces ultimately resulted in both sides achieving an assured-destruction capability, leading to a situation of "mutually assured destruction" (*see* Mutual Assured Destruction), or the "balance of terror."

Two alternative theories emerged to challenge the notion of a balance of terror. First, the idea of a *preventive* war was suggested at various points during the Cold War. This idea sought either to take advantage of the U.S. nuclear monopoly, or, later on, its overwhelming superiority, to preserve the West's strategic advantage. Once the Soviets developed an assured-destruction capability, these ideas fell into abeyance. Since the end of the Cold War, similar ideas have been espoused at times in discussions about the development of a nuclear capability by states such as Iraq, Iran, and North Korea.

The other alternative theory focused on the idea of a *preemptive* war. Although preventive war and preemptive war are similar concepts, preemption implies an attack launched against the opponent because it is thought that a strike by the other side is imminent.

—Andrew M. Dorman

See also: Cold War; Mutual Assured Destruction; Parity; Preemptive Attack

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BALLISTIC MISSILE DEFENSE ORGANIZATION (BMDO)

The Ballistic Missile Defense Organization (BMDO) was an agency within the U.S. Department of Defense charged with providing a missile defense system to protect the United States, its forces deployed abroad, and its friends and allies from ballistic missile strikes. The agency's primary missions were to provide theater missile defense (TMD) in order to address the dangers associated with short- to medium-range missile systems in regional conflicts. It was also charged with creating a national missile defense (NMD), to defend against ballistic missile attacks against the United States, as well as advanced technology developments to enhance the performance of all TMD and NMD systems.

The predecessor to BMDO, the Strategic Defense Initiative Organization (SDIO), was created by President Ronald Reagan in March 1983. The original mission of the SDIO was to explore the technical feasibility of deploying missile defense systems in the hope that such defenses might be able to defend the United States from a large-scale attack by the Soviet Union's Strategic Rocket Forces. Following the end of the Cold War, President George H. W. Bush shifted the focus of SDIO from defending the United States against a major Soviet attack to protecting against a small-scale missile attack from terrorists or rogue states. In May 1993, President William Clinton changed the name of SDIO to BMDO to reflect the changing mission of the organization.

A payload launch vehicle carrying a prototype interceptor is launched from the Kwajalein Missile Range on January 18, 2001, for a planned intercept of a ballistic missile target over the Pacific Ocean. (Department of Defense)

In January 2002, President George W. Bush again changed the name of the organization to the Missile Defense Agency (MDA). The National Missile Defense Act of 1999 called upon the United States to deploy a missile defense of the country as soon as technically possible, a responsibility that was inherited by the MDA. The MDA combines all aspects of the different missile defense systems programs (theater and national missile defenses) into a single program without regard for the recently abrogated Anti-Ballistic Missile Treaty. The new agency's director reports to the undersecretary of defense for acquisition, technology, and logistics.

—Abe Denmark

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BALLISTIC MISSILE DEFENSE

See Missile Defense

BALLISTIC MISSILE EARLY WARNING SYSTEM (BMEWS)

After the Soviets launched Sputnik in 1957, U.S. government authorities worried about a surprise missile attack on the continental United States. Thus, a more powerful set of radars, designed to warn U.S. and British strategic forces of transpolar missile attack, was added to the Distant Early Warning (DEW) Line. The program started with a prototype on Trinidad, and between 1960 and 1963 three sites were built. They were located at Thule AB, Greenland; Clear AFS, Alaska; and RAF Fylingdales Moor, Great Britain.

These radars provided the capability to detect an incoming intercontinental ballistic missile (ICBM) attack from the Russian heartland as well as submarine-launched ballistic missiles (SLBMs) fired from the Arctic and North Atlantic oceans 15 minutes before the strike was due to reach its target. Warning time to the United Kingdom from European-launched intermediate-range missiles was about 4 minutes.

The Ballistic Missile Early Warning System (BMEWS) also provided tracking data on most orbiting satellites. With the advent of warning satellites, the U.S. Air Force ensured that both space and terrestrial warning networks provided overlapping coverage and warning of foreign missile attack. The old mechanical radars were upgraded to solid-state, phased-array systems in 1987 to make the operation more effective and efficient, and they continue in operation for North American Aerospace Defense Command today.

—*Gilles Van Nederveen*

See also: Cheyenne Mountain; Distant Early Warning Line; Early Warning; Phased-Array Antenna

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BALLISTIC MISSILES

A ballistic missile is a weapon that relies on a power source to guide it into flight and then uses unguided free flight, its trajectory subject only to the forces of gravity and atmospheric drag, to reach its target. Ballistic missiles have provided a relatively fast, long-range delivery device for a number of weapons of mass destruction. There are several types of ballistic missiles. These may be characterized by range and source of launch. The main classifications are: short-range ballistic missiles (SRBMs), medium-range ballistic missiles (MRBMs), intermediate-range ballistic missiles (IRBMs), and intercontinental ballistic missile (ICBMs). An SRBM has a range of up to 1,000 kilometers (621 miles), MRBMs can reach from 1,000 to 3,000 kilometers (621 to 1,864 miles), IRBMs can threaten targets from 3,000 to 5,500 kilometers (1,864 to 3,418 miles), and ICBMs have ranges in excess of 5,500 kilometers. Ballistic missiles have various types of launch platforms, including fixed land sites such as silos, submarines (which fire submarine-launched ballistic missiles, or SLBMs), or mobile launchers such as trucks or rail cars. Ballistic missiles can carry a host of weapons, including both nuclear and conventional warheads.

A ballistic missile has several components. The missile is comprised of a propulsion system, a guidance system, a warhead (and a warhead bus, if it carries multiple warheads), and, in some cases, penetration aids. Engineers design ballistic missiles to use either liquid- or solid-fuel motors. Generally, solid-fuel systems have fewer support requirements and a higher rate of readiness than liquid-fuel systems. Most ballistic missiles also have an inertial guidance system to put the warhead close enough to destroy its target. A ballistic missile may have a single warhead or reentry vehicle (RV), or it may carry several RVs, either to hit several targets or to deploy more than one RV against a single target. Finally, a ballistic missile may possess penetration aids to ensure it defeats a ballistic missile defense system.

Today, several nations possess active missile systems or have the technical capability to develop ballistic missiles. The rationale for maintaining such weapons often includes national pride as well as a

Distant Early Warning Line station on Barter Island in the Beaufort Sea, off Alaska. (Scott T. Smith/Corbis)

military requirement for the means to deliver a significant strategic attack in a cost-effective manner. Missile proliferation, in terms of systems and technology, has increased in recent years as nations seek means to expand their security and countries use missile exports for financial gain.

History and Background

Development of the first modern ballistic missiles began before World War II. German Army engineers and scientists in 1930, under then Captain (later General) Walter Dornberger, started research to develop a liquid-fueled, long-range rocket to replace heavy artillery. By 1932, Dornberger had convinced Wernher von Braun, later a key contributor to America's space program, to join his development team. Through the 1930s, the German military designed, developed, and tested a host of missile components. These efforts led to the introduction of the Vergeltungswaffe 2 ("vengeance weapon" 2 or V-2; the German designation was A-4). The V-2 was first launched successfully on June 6, 1942. Full-scale production soon began on the 47-foot-tall missile. These missiles carried a 1,620-pound high-explosive warhead composed of cast amatol and were powered by a liquid oxygen and methyl alcohol motor that sped the rocket to a maximum range of 205 miles. The German Army eventually launched 3,255 V-2s against targets in Western Europe.

The V-2's ability to conduct strategic bombardment and defy Allied countermeasures was not lost on American and Soviet political and military leaders. The introduction of the nuclear age also played a significant role in the search for ways to deliver this new weapon. During the Cold War, the United States and the Soviet Union started an extensive program to develop operational ballistic missiles. Immediately after World War II, available technology did not exist to launch missile attacks from the continental United States against the Soviet Union or vice versa. Likewise, early missiles could not carry a sufficiently large payload to handle first-generation nuclear weapons that weighed several tons.

The United States initially focused on strategic bombers, cruise missiles, and shorter-range missiles requiring overseas basing to deliver nuclear weapons. The U.S. Air Force funded the Consolidated Vultee MX-774 project in 1946, which concluded with three test launches in 1948. This program's success sparked interest in building an ICBM. The first American ICBM was named the Atlas. In the meantime, the country focused its attention on fielding SRBM and

IRBM systems. The first SRBMs were the army's Corporal and Honest John rockets. These weapons were tactical delivery weapons that had very limited ranges. The liquid-fueled Corporal, first available for field training in 1954, had limited operational capability owing to its significant logistical requirements and the tendency of its radar/radio guidance control system to jam. The Honest John was a nuclear-armed, solid-fuel system designed to support battlefield operations.

Technological advancements and strategic demands pushed U.S. efforts to develop ICBMs. The country still required an interim capability to deliver nuclear weapons. IRBM and MRBM systems gave the nation a means to launch an attack directly on the Soviet Union or its allies. These relatively inaccurate weapon systems were primarily aimed at enemy cities and large concentrations of military forces. The army's Redstone and Jupiter systems and the air force's Thor ballistic missiles were deployed to offer a limited means to deliver nuclear weapons, but research to develop these systems also proved helpful in supporting the nascent U.S. space program. The army's Pershing I, a battlefield-deployable MRBM system, was first fielded in 1962 and served until 1985, when it was replaced by the Pershing II. The Pershing II was withdrawn from service in 1989 following the 1987 signing of the Intermediate-Range Nuclear Forces (INF) Treaty.

U.S. Intercontinental Ballistic Missiles

The United States developed four ICBM models. The first, Atlas, was a one-and-a-half-stage missile that had a maximum range of about 9,000 miles. It carried an RV with a yield of 4 megatons. Atlas D first went on alert on October 21, 1959, and the last Atlas F was retired on June 22, 1964. The two-stage, liquid-fueled Titan I ICBM started development in 1955 and began operations on September 28, 1963. An updated version, Titan II, carried the largest nuclear weapon ever deployed by the United States, with a yield of 9 megatons. The last Titan II was retired from active duty in 1987. The first solid-fueled ICBM, Minuteman, was a great advancement in reliability and logistical support. Minuteman IA was introduced into service on July 23, 1962, and the series has been improved several times in the intervening years. The Minuteman was the most successful ICBM developed by the United States. At its zenith, crews monitored 1,000 active Minuteman missile sites, with some models carrying three RVs. A single-warhead Minuteman (limited by various arms control treaties and agreements) still serves today. The most recent ICBM deployed in the United States was the Peacekeeper, a three-stage, solid-fuel system with a fourth that utilizes a storable liquid fuel. The Peacekeeper was capable of carrying up to ten RVs. It had its first test flight in 1983, was deployed in 1986, and began a three-year retirement program in 2002.

Soviet/Russian Ballistic Missiles

The Soviet Union's ballistic missile program first concentrated on copying and improving on the German V-2. This effort led to the SS-1 Scud, which has survived, in slightly more advanced versions, to this day. This SRBM has been the most widely exported ballistic missile in the world and has the capability of carrying either conventional warheads or payloads containing weapons of mass destruction. These weapons were originally designed as tactical battlefield weapons, but some countries now use them as strategic weapons. With the SS-1's success, the Soviet Union conducted an intensive program to improve its ballistic missile program in order to develop a strategic counter to America's ballistic missile and strategic bomber forces. The Soviet military thus designed, produced, and operated a series of tactical ballistic missiles mounted on various types of mobile launchers. The SS-1 entered service in 1955 with a small-yield nuclear device, and Soviet development of several IRBM and MRBM systems continued through the 1960s. Although the Soviets built these systems, they had a difficult time developing their first ICBM, the SS-6 Sapwood, and were forced to rely on their IRBM and MRBM force. Some argue that the Soviet deployment of these relatively shorter-ranged missiles on Cuba in October 1962 represented a move to improve the Soviet Union's strategic position vis-à-vis the United States and provide a counterbalance to the development of the Atlas and Titan ICBMs.

Eventually, Soviet engineers developed many ICBM models. As in the United States, Soviet programs evolved from liquid-fueled to solid-fueled systems. The Soviets' first successful ICBM was the SS-7 Saddler, which was deployed in 1961 and served until 1979. The Soviets then developed a series of systems, from the SS-8 up to the SS-25. The SS-18 Satan was the largest Cold War ICBM deployed by either side. The missile was designed to carry a single 20-megaton yield nuclear weapon or ten 500-kiloton RVs. The last Soviet ICBM was the road-mobile, single-warhead SS-25 Sickle, deployed in 1982. Since the dissolution of the Soviet Union, Russia has introduced the SS-27 Topol, a solid-fueled silo or road-mobile missile that possesses countermeasures to ballistic missile defenses.

Submarine-Launched Ballistic Missiles

SLBM development progressed in both nations as well. The United States first used submarine-launched cruise missiles but produced Polaris ballistic missiles in 1960. The first Polaris SLBM had a range of about 1,600 miles. These missiles originally had a single warhead, but later versions had three. The U.S. Navy later improved the Polaris with the longer-range Poseidon, which carried ten RVs. Poseidon began service in 1971. The current U.S. SLBM is the Trident, which entered service in 1979 as C-4. The Trident II D5 has improved range, yield, and accuracy that approach the parameters of land-based ICBMs. The Soviet Navy started deployment of SLBMs in 1955 with an SS-1 converted for naval use. The Soviets went to sea with a number of SLBMs. The first to have ICBM range was its SS-N-8 in 1971. Today, the Russian Navy operates the SS-N-18, the SS-N-20, and the SS-N-23, all containing multiple RVs. The SS-N-23 is the only solid-fueled SLBM and has ten RVs.

Other Countries

During the Cold War, other nations also acquired ballistic missiles. The United Kingdom acquired Thor IRBMs and the Polaris and Trident SLBMs from the United States. It eliminated its Thor force in 1964. France developed its own nuclear ballistic missile force, which included land-based IRBMs and SLBMs. It still maintains its SLBM force today, although it retired its IRBMs in the 1990s. The Soviet Union sold Scud technology to a number of countries throughout Eastern Europe and to North Korea. North Korea, in turn, has sold this technology to other nations. North Korea is one of world's largest proliferators of missile technology. India, Pakistan, and Iran have sought to acquire MRBMs or IRBMs to deliver weapons of mass destruction. China has developed a range of ballistic missiles, from SRBMs to ICBMs, and is attempting to deploy an SLBM force.

Accuracy

Missile characteristics such as payload, range, and reliability are important. However, accuracy may be the most important consideration in determining the military value of a ballistic missile. Missileers use "circular error probable (CEP)" as a means to measure performance. CEP is the radius of a circle within which half of all weapons targeted for the center are expected to fall. Many developing nations have ballistic missiles that might have a CEP of several miles, even if fired from only 100 miles away. U.S. missiles, however, have sophisticated guidance systems allowing them to strike targets across continents with a CEP of only a few yards.

Current Status

More than two dozen nations possess ballistic missiles. The United States and Russia have the largest arsenals of ICBMs and SLBMs. Since the introduction of the Scud, some twenty-nine nations have purchased or used its technology to develop their own Scud versions. The vast majority of these are SRBMs. However, a number of nations seek longer-range ballistic missiles that can strike targets within their region and potentially attack global targets. Several nations seeking the capability of launching satellites may hope to use satellite boosters as ballistic missiles to carry weapons payloads.

North Korea, Iran, and Pakistan are the leading nations seeking to improve their ballistic missile technologies. North Korea, in particular, has made the greatest advances toward developing ICBMs. China and Russia also have active ICBM and SLBM programs.

—Clay Chun

See also: British Nuclear Forces and Doctrine; Chinese Nuclear Weapons; Depressed Trajectory; Downloading; Indian Nuclear Weapons Program; Iranian Nuclear Weapons Program; Missile Defense; North Korean Nuclear Weapons Program; Pakistani Nuclear Forces; Reentry Vehicle; Russian Nuclear Forces and Doctrine; United States Nuclear Forces and Doctrine; Warhead

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BARUCH PLAN

On June 14, 1946, the U.S. representative to the recently created United Nations Atomic Energy Commission, Bernard M. Baruch, presented a U.S. proposal for controlling nuclear weapons. This was the first nuclear arms control proposal in history and drew on the work of a team led by then Undersecretary of State Dean Acheson and David Lilienthal, soon to become the first chairman of the U.S. Atomic Energy Commission. The major technical contributions to the plan were made by J. Robert Oppenheimer, the physicist who had been the science leader of the World War II project to develop the atomic bomb (*see* Manhattan Project).

Aside from the technical details of the Baruch Plan, the event was significant in several important respects. It represented a difficult decision by the United States to give up its sole possession of the atomic bomb if an acceptable political regime to control the new weapon could be established. It sought to pursue arms control through the multilateral channels of the newly created United Nations instead of first negotiating details bilaterally with the Soviet Union. It recognized the uniquely threatening character of nuclear weapons by proposing to set aside the Security Council veto for nuclear matters. And when the plan was debated, the question of the legitimacy of anticipatory defense was raised at the United Nations for the first time.

Recognizing that the key to nuclear weapons production was obtaining fissile materials, the plan called for creation of an International Atomic Energy Development Authority, to which would be entrusted all phases of the development and use of atomic energy, starting with the raw material. When an adequate system for control of atomic energy, including the renunciation of the bomb as a weapon, had been agreed to and put into operation, and when sanctions had been set up for violations of the rules of control (violations that would be stigmatized as international crimes), then national manufacture of atomic bombs would stop, existing bombs would be disposed of pursuant to terms of the treaty, and the Authority would possess full information on how to produce atomic energy.

The Soviet Union objected to the phased approach, insisting that stockpiles first should be destroyed and possession or use of nuclear weapons characterized as an international crime, prior to establishing a technical control regime. Talks quickly stalemated as the Cold War set in. Although some critics have argued that with a different approach to the negotiations the United States might have secured a compromise, most scholars of the Baruch Plan today recognize that Soviet leader Joseph Stalin was set on acquiring nuclear weapons, negotiations notwithstanding.

Nuclear arms control progressed in later years through bilateral and multilateral channels and remains one of the main issues on the international agenda.

—Michael Wheeler

See also: Atomic Energy Commission

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BASELINE INSPECTION

See Verification

BETA PARTICLE

See Radiation; Radiation Absorbed Dose (RAD)

BIKINI ISLAND

Bikini Island is an atoll in the Ralik chain of the Marshall Islands in the Western Pacific Ocean that was used for early atomic testing by the United States. North of the equator and 225 miles northwest of Kwajalein, the atoll consists of islands only 7 feet above sea level forming a ring around a 15- by 25-mile lagoon, comprising 2 square miles of dry land. Before World War II, the atoll was known as Escholtz Atoll. It was occupied by Japan until 1944 and administered by the United States from 1947 to 1979 as part of the Trust Territory of the Pacific Islands under a United Nations trusteeship. In 1979, it became a part of the Republic of the Marshall Islands.

In 1946, Bikini became the site of Operation Crossroads, a joint military and scientific project to determine the impact of nuclear bombs on naval vessels. The 166 native Micronesians living on the atoll had to be relocated to Kili Island, about 500

Underwater atomic blast in Bikini Lagoon, Marshall Islands, July 1946. (Library of Congress)

miles southeast. On July 1, 1946, Bikini became the site of the world's first peacetime atomic weapon explosion. With eighty retired battleships and aircraft carriers as targets, a 20-kiloton atomic bomb was dropped from an airplane. On July 25, 1946, the world's first underwater atomic explosion took place nearby, raising a column of radioactive water that sank nine ships.

From 1954 through 1958, Bikini and Enewetak Atoll, which is located about 150 miles southwest of Bikini, became the Pacific Proving Ground for the U.S. Atomic Energy Commission. Tests included thermonuclear devices, and in 1956, the first hydrogen bomb was dropped near Bikini by a U.S. airplane. The tests resulted in severe radioactive contamination of the atoll.

In the 1960s, some of the original islanders tried to return to Bikini, but the radiation levels proved unsafe. In 1969, the United States began work on a long-term project to reclaim the islands. The islanders filed a suit against the government in 1985, and as a result of this action, the U.S. government funded a cleanup that started in 1991. The first radiation cleanup project was completed in 1998. Although radiation levels were too high for residence, in 1996 the Bikini Lagoon was reopened for scuba diving, and in 1998 sport fishing was again permitted.

—*Frannie Edwards*

See also: Kwajalein Atoll

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BOMBERS, RUSSIAN AND CHINESE NUCLEAR-CAPABLE

During the Cold War, both the Soviet Union and the United States developed a "Triad" of nuclear delivery systems consisting of intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and manned bombers. Although in Soviet doctrine the ICBM became the primary means of nuclear deterrence, for many years the Soviet Union's only means of delivering nuclear weapons was the manned bomber. Even as aircraft fell out of favor as the main delivery system, the Soviet Air Force continued to maintain a heavy bomber fleet, and Russia, as the successor state to the Soviet nuclear arsenal, still maintains a bomber fleet, though it is only a fraction of the size of the Soviet force at its height.

Chinese nuclear doctrine, which calls for minimal deterrence, relies heavily on ballistic missiles as delivery vehicles. Chinese officials have announced that in the future they do not intend to rely on bombers as nuclear delivery vehicles. Nevertheless, China maintains a small force of theater bombers that could be used to deliver nuclear-capable gravity weapons.

Soviet Union/Russian Bombers

Following the detonation of its first atomic bomb on August 29, 1949, the Soviet Union possessed nuclear weapons but lacked the means to deliver them. Until the development of a useful ICBM, the Soviets relied on a series of manned bombers to supply a nuclear deterrent capability.

Tupolev Tu-4 (NATO Designation: Bull)

As early as September 1943, the aviation design bureau headed by A. N. Tupolev was authorized to start work on a new strategic bomber based on the American B-29 Superfortress. The result was the Tupolev Tu-4 (NATO designation: Bull). The Tu-4 entered series production in 1947 and entered active service in 1949. With a range of only 6,200 kilometers (km) (3,348 nautical miles [nm]), it could not reach the continental United States from interior Soviet bases. While aerial refueling technology, and some efforts at intermediate basing on the Arctic icecap, provided some marginal enhancement of the Tu-4's capabilities, a completely new aircraft was needed to perform the strategic nuclear strike mission

Myasishchev M-4 (NATO Designation: Bison)

Production of V. I. Myasishchev's M-4 turbojet bomber (NATO Designation: Bison) began in 1954. In 1956, the M-4 underwent a major redesign that provided the aircraft with improved engines that extended its range to 12,000 km (6,480 nm). Only 116 Bison bombers of all versions were produced through 1960, and there were never more than 60 aircraft in the operational inventory at any one time.

Tupolev Tu-95 (NATO Designation: Bear)

While Myasishchev was working on his turbojet design, Tupolev was working on a fundamentally different aircraft. Tupolev's research had shown that the same performance as a turbojet could be achieved with a turboprop engine. Entering service in 1956, the Tu-95 (NATO Designation: Bear) was the Soviet Union's first intercontinental bomber; its turboprop engines gave it greater range than the jet engines of the day. Spawning nine different variants, the Tu-95 continues in service today.

Tupolev Tu-160 (NATO Designation: Blackjack)

By the late 1970s, the bomber leg of the Soviet Triad was clearly the least important, behind the ICBM force and the SLBM fleet, and in many respects it was approaching obsolescence. Responding to the Kremlin's call for a new supersonic bomber, Tupolev developed plans for a variable geometry wing aircraft called Aircraft 70 (NATO Designation: Blackjack). Very similar in appearance to the U.S. B-1A, though larger and heavier, the new design first flew in 1981. Eventually designated as the Tu-160, the Blackjack entered series production in 1984. Although original plans called for 100 aircraft, production halted in 1992 following the collapse of the Soviet Union after only 36 aircraft had been built. Production resumed in 1998, and the first new aircraft entered service in May 2000.

Bomber Development Lags

The primacy of Long Range Aviation in the strategic nuclear force began to decline in the late 1950s. U.S. B-29 losses during the Korean War suggested that bombers could not survive modern air defenses. The Soviets also were concerned about command and control once the bombers left Soviet airspace and the pilots controlled the release of nuclear weapons. These issues, coupled with the successful launch of intercontinental-capable ballistic missiles, spelled the end of the primacy of the Soviet bomber force.

At the same time that new bomber designs were being developed, advances in cruise missile technology promised to give the bomber new life as a strategic nuclear delivery vehicle. In 1968, the Soviets conducted a study to examine future trends in strategic weapons. It focused on the use of a small, subsonic weapon on the premise that a smaller weapon would allow a delivery system to carry more. The result was the Kh-55 air-launched cruise missile (ALCM) (NATO designation: AS-15 Kent). The Soviets, however, now needed to develop an aircraft capable of delivering the cruise missile system. The Tu-160 was the aircraft most likely to carry the new missile, but in the late 1970s and early 1980s that aircraft was still undergoing flight tests. Considering it infeasible to upgrade the existing Tu-95M to carry the Kh-55, the Soviets opted to build a new aircraft, the Tu-95MS (NATO designation: Bear H), based on the Tu-142 currently in service as an antisubmarine warfare and maritime reconnaissance aircraft. Although only a low-cost, stopgap measure until the Tu-160 was brought on line, the Tu-95MS has shouldered the cruise missile carrier burden since the Soviet collapse and the end of Tu-160 production.

Theater Bombers

While developing its intercontinental bomber force, the Soviet Union also built a theater bomber force capable of threatening targets close to home. Tupolev began designing a replacement for the Tu-4 while work continued on the Tu-95 intercontinental bomber. Serial production for the design, which became the Tu-16 (NATO Designation: Badger), began in 1953 and ended in 1963 after 1,509 aircraft had been built. Soon after its delivery to line units in 1954, the Tu-16 became the primary Soviet theater bomber, serving with Soviet Air Force and Soviet Naval Aviation units until its retirement in 1993. The Tu-16 was a very successful design and underwent seven modifications that adapted the aircraft to carry improved weapons, particularly missiles. The Tu-16A was designed to carry free-fall nuclear bombs. In addition, the Soviets developed a unique wingtip-to-wingtip refueling system for the aircraft, modifying some Tu-16s, known as Tu-16Zs, to serve in the tanker role.

After Tu-16 serial production began in 1953, Tupolev began work on a new supersonic bomber design. Billed as the replacement for the Tu-16, the Tu-22 (NATO designation: Blinder) was, in fact, capable of carrying a similar payload to the Tu-16, but only to a slightly greater range. Before production ended in 1969, 300 Tu-22s were built. Ukraine is believed to be the only country currently operating the aircraft.

Despite his lack of success improving the Tu-22's performance, Tupolev continued to work on a new medium-range bomber. The result was an aircraft with variable sweep wings and a subsonic range claimed to be 6,000–7,000 km (3,254–3,780 nm). First flown in 1969, the Tu-22M (NATO designation: Backfire) was adopted by both the Soviet Air Force and Naval Aviation in 1976. The aircraft was a subject of controversy during early Strategic Arms Limitation Talks (SALT I). The Soviets agreed to remove the aircraft's air refueling probes and to limit production to thirty aircraft per year as part of the SALT I agreement.

Russia currently maintains a bomber inventory including 74 Tu-95MSs, 15 Tu-160s, and 117 Tu-22Ms, a mere shadow of the old Soviet bomber force. Plagued by shortages of spare parts and fuel, the bomber force finds it difficult to keep its aircraft flyable. These shortages have contributed to a training crisis among bomber crews. In 1998, Russian bomber crews averaged only about twenty-one hours of flying time per year, compared to twenty-five hours per *month* in the U.S. Air Force. Still, the bomber force remains a key portion of Russia's nuclear deterrent capability. Russia also acknowledged the importance of airpower in rapid reaction operations. To this end, Russia reorganized Long Range Aviation into the 37th Air Army in 1998. This organization is tasked with the delivery of both nuclear and conventional ALCMs (*see* Russian Nuclear Forces and Doctrine; Strategic Forces).

Chinese Bombers

Founded in 1949, the People's Liberation Army Air Force (PLAAF) received significant Soviet aid prior to the 1960 Sino-Soviet split. Having only 100 aircraft at its birth, the PLAAF began to receive this aid as a result of its large losses (2,000 aircraft) during the Korean War. The Soviets rebuilt World War II Chinese aircraft production facilities in Shenyang and Harbin, equipping them with the latest in Soviet production technology. These facilities had produced combat aircraft in the 1930s and 1940s but had been stripped by the Soviets in 1945. At the same time, the Soviets provided production licenses, drawings, and tools: everything the Chinese needed to build aircraft. As part of this exchange, China received licenses to produce its two main bomber aircraft, the Hong-5 and the Hong-6.

China's decision to develop an independent strategic nuclear force was probably made by early 1956. In 1964, China detonated its first nuclear weapon, and within months it established the Second Artillery, the organization responsible for controlling China's ballistic missile forces. In 1966, China launched its first medium-range ballistic missile (MRBM). It was capable of carrying a 20-kiloton nuclear warhead. Meanwhile, the Hong-6, based on the Soviet Tu-16 medium-range bomber, entered service in 1968 and reached an inventory of 100 aircraft by 1972. Capable of carrying a single 1-megaton bomb, the Hong-6 force grew only slowly, with developers emphasizing qualitative improvements over quantity, while China continued to improve its ballistic missile force. The decision to focus on ballistic missile forces over bomber forces may have reflected concerns over bomber survivability. Improvements in air defense capabilities likely suggested to the Chinese that the manned bomber would not make it to the target.

Table B-1: Russian Nuclear Bombers

Aircraft Models	Tu-22M (NATO: Backfire) Tu-22MO Tu-22M-1 Tu-22M-2 Tu-22M-3	Tu-95MS (NATO: Bear H) Tu-95MS6 Tu-95MS16	Tu-160 (NATO: Blackjack) Tu-160
Crew	4	7	4
Speed	Cruise: 485 kts Max Level: Mach 1.88 (1,080 kts) at high altitude	Cruise: 384 kts Max Level: 447 kts at 38,000 ft	Cruise: 518 kts at 45,000 ft Max Level: Mach 2.05 (1,200 kts) at 48,000 ft
Combat Radius	1,300 nm (subsonic high-low-high mission profile)	3,455 nm (unrefuelled) 4,480 nm (with one refueling)	1,080 nm at Mach 1.5
Defensive Armament	2 X tail mounted twin Gsh-23 23mm cannon	1 or 2 X tail mounted 23mm cannon	None
Weapons Load	3 X Kh-22 missiles or 52,910 lbs conventional bombs or mines internally and on wings or 6 X Kh-15P SRAMs	Tu-95MS16:16 X Kh-55 or RVK-500B ALCMs Tu-95MS6: 6 X Kh-55 or RVK-500B	12 X Kh-55 ALCMs OR 12-24 Kh-15P SRAMs
Air Refueling Capable	No	Yes	Yes

China now maintains a small bomber fleet while emphasizing the other elements of the Triad. It has a bomber force of 40 Hong-5s and 110 Hong-6s; only about 100 Hong-6s, however, are part of China's nuclear force, and some sources indicate that all Hong-5 aircraft are now dedicated to training. Some A-5 Fantan short-range attack aircraft are also used in the nuclear delivery role.

Technical Details

Emerging Technologies

Russia currently operates the Tu-95MS, Tu-160, and Tu-22M, as shown in Table B-1. China currently operates only two medium bomber aircraft: the Hong-5 and Hong-6. Technical details of these aircraft are shown in Table B-2.

There have been rumors of a new Russian bomber since the early 1980s. Little is known about this aircraft, although it is believed to incorporate low observable technology and have two thrust-vectoring turbofans. Russia's lack of hard currency, however, has led some observers to believe that military aircraft are increasingly designed for export. Security concerns make it unlikely that Russia would offer a nuclear-capable bomber for export, thus pushing further bomber development into the more distant future. It is more likely Russia will upgrade existing aircraft, improve weapons delivery capabilities, and develop new cruise missiles to improve strategic bombers' standoff capability.

Table B-2: Chinese Nuclear Bombers

Aircraft	Hongzhaji-5/ Hong-5/B-5 "Beagle"	Hongzhaji-6/ Hong-6/B-6 "Badger"
Soviet Equivalent	Il-28 (NATO: Beagle)	Tu-16 (NATO: Badger)
Models	H-5	H-6A B-6D
Crew	3	6
Speed	Cruise: 415 kts Max Level: 487 kts at 14,760 ft	Cruise: 424 kts
Range	1,176 nm at 32,800 feet	2,320 nm
Defensive Armament	2 X forward firing 23mm NR-23 cannon 2 X tail mounted 23mm NR-23 cannon	6 or 7 guns mounted in dorsal, ventral, and tail positions

At one time strategic bombers made up 45 percent of the Chinese nuclear delivery capability, but changes in Chinese nuclear doctrine in the late 1960s and early 1970s shifted the emphasis on nuclear delivery toward intercontinental and short-range ballistic missiles. By the late 1990s, further doctrinal evolution suggested the Chinese intended to rely increasingly on submarine-launched ballistic missiles. In addition, the economic importance of China's space program may also have influenced the Chinese decision to base strategic nuclear modernization efforts on improved missile technology. Although the Chinese expressed an interest in acquiring the Tu-22M from Russia, as of 2004 there were no indications that the Soviets will sell the bomber. Instead, China is concentrating on developing newer fighter and fighter-bomber aircraft.

—*Rob Melton*

See also: Chinese Nuclear Weapons; Russian Nuclear Forces and Doctrine; Strategic Forces

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BOMBERS, U.S. NUCLEAR-CAPABLE

Bombers are long-range aircraft that can carry large amounts of nuclear or conventional ordnance. The United States has designed, developed, produced, and operated several types of bomber aircraft for the primary mission of delivering nuclear weapons. During the Cold War, bombers, along with intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles (SLBMs), were a key element of America's strategic "Triad," serving as the U.S. nuclear deterrent against Soviet aggression. National leaders created specialized organizations, infrastructure, support aircraft, and systems devoted solely toward ensuring that these aircraft could reach an adversary's homeland and drop a nuclear device or launch a nuclear-armed missile against a foe. The strategic bomber was the first weapons platform to shoulder the burden of carrying nuclear weapons, and it did so for years even as ballistic missiles were deployed. Advances such as stealth technology, jet engines, and the advent of aerial refueling continue to make long-range bombers an important nuclear delivery system.

History and Background

The evolution of nuclear-armed bombers began with the use of the Boeing B-29 Superfortress, an aircraft designed in World War II to carry conventional weapons. Crews flew this aircraft to drop the 13-kiloton Little Boy atomic bomb that destroyed Hiroshima on August 6, 1945, and the 23-kiloton-yield Fat Man that shattered Nagasaki eight days later. The B-29 and a variant, the B-50, then served as the U.S. Air Force's only nuclear-capable bombers, under the Strategic Air Command, well into the early 1950s. Despite improvements to the propeller engine aircraft and the refinement of operations such as aerial refueling, they were too slow to avoid jet interceptors and lacked the range to hit targets from bases in the continental United States (*see* Fat Man; Little Boy).

The air force developed several aircraft to replace the B-29 and B-50 during the 1950s. The massive Consolidated B-36 Peacemaker was a six-engine propeller aircraft that was the first truly intercontinental bomber, and it was the largest bomber ever to enter operational service. Later versions had four auxiliary jets for a total of ten engines. The aircraft had a 10,000-mile range. The U.S. Air Force, which had to penetrate increasingly sophisticated Soviet air defense systems, needed a more responsive bomber fleet, however, and started work on a jet bomber. The Boeing B-47 Stratojet was a swept-winged craft that first flew operational missions in 1951. Using aerial refueling, this aircraft had intercontinental range. More B-47s have been produced in the years since World War II than any other bomber. The air force also designed, produced, and deployed the longest-serving bomber, the Boeing B-52 Stratofortress. It accepted the first production B-52 in

B-52G Stratofortress carrying air-launched cruise missiles. (Department of Defense)

1954. The B-52 has eight turbofan engines and is capable of dropping nuclear and conventional gravity weapons and guided missiles. This aircraft stood nuclear alert for decades and served as a conventional bomber in conflicts from Vietnam to Afghanistan. Its latest variant, the B-52H, remains on duty today.

Throughout the 1950s and 1960s, the U.S. Air Force and U.S. Navy also designed or deployed nuclear-capable jet aircraft with relatively limited operational ranges and payloads. Development of smaller nuclear bombs allowed tactical aircraft to carry such weapons to strike a host of potential targets. The U.S. Air Force purchased the North American B-45 Tornado, a British-designed Martin Marietta B-57 Intruder, and the Douglas B-66 Destroyer. The U.S. Navy deployed the Douglas A-3 Skywarrior (the U.S. Air Force B-66 was a variant of this aircraft) and the supersonic North American A-5 Vigilante. The A-3 and A-5 were carrier-based aircraft and provided the U.S. Navy with a strategic bomber force.

As Soviet air defenses improved, the U.S. Air Force demanded bombers that flew at higher speeds and altitudes. These requirements led to the introduction of the supersonic Convair B-58 Hustler in 1960. Rapid advances in Soviet surface-to-air missiles, radar, and improved jet interceptors soon negated the plane's ability to outfly air defenses. In addition, the plane's continuing operational problems forced the service to retire the jet within ten years. Advancements in ballistic missiles, cost, technical problems, and the change in Soviet defense capabilities also forced the John F. Kennedy administration to cancel the ambitious North American B-70 supersonic bomber about the same time.

In the 1970s, the sole supersonic operational bomber deployed by the United States was a version of the controversial General Dynamics F-111 fighter. The FB-111 Aardvark could reach speeds of Mach 2.5 but had a much smaller payload than the B-58. The U.S. Air Force purchased FB-111s to replace older B-52s and the retiring B-58. They served as an interim bomber force until the service's advanced B-1 was made operational.

The Rockwell International B-1 Lancer was controversial from its program start. Technical concerns, cost, and political debate forced its cancellation by President Jimmy Carter on June 30, 1977. President Ronald Reagan reversed this decision in 1981. The aircraft was redesigned to become a penetrating bomber with some stealth capability. Only 100 were built as a short-term replacement for a more advanced radar-evading aircraft, the Northrop B-2 Spirit. The B-2 was designed to defeat enemy air defenses and deploy conventional or nuclear weapons. Post–Cold War demobilization forced severe program cuts, and the U.S. Air Force purchased only 21 operational aircraft—at a cost of approximately $2 billion each.

U.S. Bombers Today

U.S. Air Force bombers today can deploy a range of nuclear weapons, including the AGM-86 air-launched cruise missile, the AGM-129 advanced cruise missile, and a number of gravity-delivered nuclear bombs. Serving B-2 and B-52 aircraft possess a nuclear capability. Owing to arms control restrictions, the B-1 can only carry conventional weapons. As of January 2003, the U.S. Air Force maintains 85 B-1s (plus one in the Air National Guard), 21 B-2s, and 85 B-52s (plus 9 in the U.S. Air Force Reserve) in its inventory.

Currently, the Air Force does not have a bomber replacement in development for the B-1, B-2, or B-52. Continual improvements in avionics, standoff weapons, service life, and other modifications have extended the operational service of all three bomber types.

—Clay Chun

See also: Airborne Alert; Stealth Bomber (B-2 Spirit); Strategic Air Command and Strategic Command; United States Nuclear Forces and Doctrine

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BOOST-PHASE INTERCEPT

The term “boost-phase intercept” (BPI) refers to programs, strategies, and systems designed to intercept ballistic missiles during the course of their initial phase of flight, beginning with ignition and lasting through that period of time during which the missile’s stages are firing and providing thrust. The boost phase can last anywhere from 20 to 240 seconds, depending on the type and range of the missile. From the point of view of developing an effective missile defense system, there are distinct advantages to attempting to intercept a missile during this phase, but there also are daunting technical challenges involved. The advantages include the fact that a ballistic missile is traveling at its slowest speed while accelerating, the missile’s exhaust plume is bright and hot against the atmosphere and the surface of the Earth and thus more easily detected and tracked, and any countermeasures the missile might be carrying will not yet have been deployed. In many respects, a ballistic missile is at its most vulnerable during its boost phase. Having the capability to intercept missiles during this phase can contribute to a layered defense; if a missile fails to be intercepted during this phase, there remain the midcourse and terminal phases during which additional attempts can be made to intercept it.

Achieving an intercept during the boost phase is technologically very challenging. Since this phase of the missile’s flight is so short, there is very little time available for the process, which includes detecting its launch, tracking its flight, determining whether it is hostile, deciding whether to launch an interceptor missile or initiate some other interception method (such as using an airborne laser), and actually reaching the ascending and accelerating missile with another missile or kill mechanism. This approach thus places maximum stress on command and control systems and on the acceleration capacities of interceptor missiles, since their acceleration often must be many times that of the missiles they are intended to intercept. To be effective, a BPI system probably needs to be located very close to the bases from which the targeted missiles are launched.

Sea-based BPI systems have the advantage of mobility; they can be deployed off the shores of a hostile nation and relocated as circumstances require. They can also be deployed closer to the launch point, making early interception during the boost phase more likely. The United States is currently developing a very fast acceleration missile for deployment on navy ships intended as a boost-phase interceptor. Sea-based systems, however, would be ineffective against missiles launched from deep within a hostile nation’s territory.

Space-based BPI systems, if developed, could orbit over any part of the Earth’s surface, providing global reach. The United States is pursuing long-range research and development into both a kinetic kill space-based intercept capability (designed to physically ram hostile missiles) and a directed-energy space-based system (which would employ laser beams or focused X-rays to destroy a missile). But the first tests of prototypes for such systems are ten to twelve years off, and their effectiveness has yet to be validated.

—John Spykerman

See also: Ballistic Missiles; Missile Defense

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BOTTOM-UP REVIEW

U.S. Secretary of Defense Les Aspin initiated the Bottom-Up Review (BUR) in March 1993 in response to the dramatic changes that occurred in the international security environment following the collapse of the Soviet Union and the end of the Cold War. It was a comprehensive review of U.S. defense strategy, force structure, infrastructure, and modernization plans.

Issued in September 1993, the review was supposed to offer a way to reduce defense spending while gradually transforming and modernizing the U.S. military for the "long peace" that was expected to follow the end of the Cold War. Although it called for reducing the size of the U.S. military, it failed to break with many traditional planning assumptions. It maintained current military capability against familiar, if vanishing, threats but did not preserve long-term U.S. military capability or focus on new dangers. It kept the requirement to wage two nearly simultaneous major regional conflicts and concentrated on improving U.S. capabilities to re-fight the Gulf War (capabilities that ironically came in handy nearly a decade later). It failed to increase U.S. peacekeeping forces and unconventional operations, however, capabilities that many analysts believed were needed to deal with the instability that emerged following the collapse of Soviet power. Advocates of the so-called revolution in military affairs (RMA) also believed that the BUR failed to exploit the information revolution.

Ultimately, the BUR created an unaffordable force. Given a defense budget that remained flat throughout the 1990s, the existing force structure and modernization plans contained in the BUR exceeded the amount the U.S. Congress was willing to spend on defense. Yet the Bottom-Up Review process was deemed valuable enough to warrant major reviews of America's defenses at regular intervals over the next decade through the Quadrennial Defense Reviews.

—James J. Wirtz

See also: Quadrennial Defense Review

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BREAKOUT

See Arms Control

BRILLIANT EYES

Brilliant Eyes, a spacecraft research and development program pursued by the United States from 1990 to 1994, was an element of the layered ballistic missile defense system envisioned by the Strategic Defense Initiative Organization (SDIO). It was intended to be deployed as a constellation of satellites designed to track reentry vehicles (RVs) during exoatmospheric flight and to help discriminate RVs from penetration aids using infrared and visible-light sensors.

Tracking RVs during exoatmospheric flight (rather than using only tracks from the missile plume) enables early intercept attempts and impact prediction, verifies an actual missile attack by tracking the warheads, and provides long-term tracking of the motions and characteristics of the set objects resulting from a launch. The resulting "birth-to-death tracking" enhances the ability to discriminate RVs from the rocket bodies, debris, and penetration aids that may accompany a ballistic missile launch.

The whimsical name Brilliant Eyes was derived from the space-based interceptor program Brilliant Pebbles, under way at the same time. Brilliant Eyes was one in a series of programs, starting in the late 1970s and continuing to the present, intended to develop systems capable of tracking relatively cold RVs and spacecraft as they move through space. These programs include the Space-Based Surveillance System, the Space Surveillance and Tracking System, Brilliant Eyes, the "SBIRS-Low" component of the

Space-Based Infrared System, and, as of 2004, the Space Tracking and Surveillance System (STSS).

—*Roy Pettis*

See also: Missile Defenses; Reentry Vehicles; Strategic Defenses

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BRILLIANT PEBBLES

See Strategic Defense Initiative

BRINKMANSHIP

Brinkmanship is a policy of creating a crisis so that one party knowingly challenges another in the expectation that the adversary will back down in the face of this challenge. The purpose of such a policy is to achieve specific political objectives by means of coercion or the possibility of escalation to war. Although the escalatory cycle is employed in inducing a crisis, the policy is a success when war is avoided and the opponent complies without a fight.

Brinkmanship has sometimes been undertaken without good evidence that the adversary would back down, forcing the party generating a crisis to back down, which adversely affects its own credibility and deterrence posture. Factors inducing states to consider employing brinkmanship, and therefore increase the risk of war, can come from either foreign or domestic sources. In terms of external threats, an important motive that can prompt leaders to embark on a brinkmanship policy is the expectation of a considerable shift in the balance of power that would leave them worse off. This probably was a primary motive behind Soviet Premier Nikita Khrushchev's decision to install missiles on Cuba as a response to the first-strike capability of the United States.

An alternate explanation for adopting a brinkmanship policy springs from the need of leaders and states to divert attention from domestic problems by securing achievements in foreign affairs. North Korea's policy of nuclear brinkmanship that began in the 1990s might be an effort to divert domestic attention away from a myriad of problems while seeking to extract tangible benefits from the international community by threatening to develop weapons of mass destruction.

—*J. Simon Rofe*

See also: Cold War

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BRITISH NUCLEAR FORCES AND DOCTRINE

The United Kingdom of Great Britain and Northern Ireland maintains a declared independent nuclear deterrent, relying solely on Trident submarines with ballistic missiles, in conjunction with the U.S. Navy. The United Kingdom is one of only two European Union countries to possess and deploy nuclear weapons, the other being France.

History and Background

Until 1945, Britain collaborated with the United States in the research and development of atomic technology. It was actively involved in civilian research prior to World War II through individuals such as Ernest Rutherford and in experiments with heavy water and nuclear accelerators, and during World War II as part of the Manhattan Project—a joint U.S.-UK endeavor (*see* Heavy Water; Manhattan Project). In 1945, British officials, presiding over a shrinking empire and anxious to arrest the nation's decline in world politics, realized the significance of the nuclear bombs dropped on Hiroshima and Nagasaki and decided to proceed with atomic research, with the aim of producing atomic bombs, using plutonium as the fissile material. When the United States passed the McMahon Atomic Energy Act (1946) forbidding the transfer of nuclear weapons technology to other nations, Britain boosted its efforts at the Atomic Weapons Establishment (Aldermaston, Berkshire) for an independent nuclear weapons program. It made the decision in 1947 to build and test an atomic weapon. Through agreement reached with Australia, Britain successfully tested its first 25-kiloton nuclear device aboard a ship moored off the northwest coast of Australia, near Monte Bello Islands, on October 3, 1952. This was followed by Britain's first hydrogen bomb test in 1957 in the Pacific Ocean. Renewed collaboration with the United

Britian's V-Bomber trio—the "Vulcan," "Valiant," and "Victor"—flying in formation over southern England, 1957. (Hulton-Deutsch Collection/Corbis)

States led to the transfer of nuclear propulsion technology. Subsequent joint U.S.-UK nuclear warhead tests continued between 1962 and 1991.

Initially it was envisaged that the British independent nuclear deterrent would be airborne, with free-fall gravity bombs delivered by the V-force bombers (Valiant, Victor, Vulcan). The introduction of the Tornado aircraft into Royal Air Force service in 1978 saw a continuation of this doctrine, with eight operational squadrons of multirole, dual-capable Tornado GR.1/1A aircraft, until the withdrawal of the last remaining WE177 bombs from operational service in March 1998. This terminated the Tornados' nuclear role, bringing to an end a four-decade history of RAF aircraft carrying nuclear weapons. By the end of August 1998, all remaining WE177 bombs had been dismantled.

Britain acquired a seaborne independent nuclear deterrent at the same time that its RAF program was in operation. Following the cancellation of the U.S. Skybolt program as an air-launched nuclear ballistic missile for the Vulcan aircraft, President John F. Kennedy and Prime Minister Harold MacMillan signed the Nassau Agreement in December 1962. Under this treaty, Britain acquired a Polaris nuclear submarine fleet for the Royal Navy. The doctrine since the purchase of Polaris has remained unchanged: "Britain's strategic nuclear force has been committed to NATO [North Atlantic Treaty Organization] and targeted in accordance with Alliance policy and strategic concepts under plans made by the Supreme Allied Command Europe (SACEUR)" (*Strategic Defence Review,* para. 4). NATO's concept of nuclear deterrence is in turn based predominantly on U.S. nuclear doctrine. The Polaris fleet has been replaced by a Trident submarine fleet, the first of which entered into service in 1994. (The last Polaris was retired in 1996.) The British Army during the Cold War also manufactured artillery shells and land mines that could have had nuclear components for tactical use in compliance with NATO's doctrine of the "Triad of Forces," but these were never independently tested or deployed.

The United States deploys tactical nuclear weapons in seven NATO European countries, including Britain, and has agreements with these countries allowing them to take control of the weapons and use them in a state of war. At no stage has Britain ever used nuclear weapons in combat, and it is a party to the Nuclear Nonproliferation Treaty (1968), the Limited Test Ban Treaty (1963), the Outer Space Treaty (1967), the Seabed Arms Control Treaty (1971), and the International Code of Conduct for Ballistic Missiles (2002).

Britain's Nuclear Deterrent Force Today

Britain today maintains a nuclear deterrent posture based solely on nuclear-powered ballistic missile submarines (SSBNs). The first submarine of the Vanguard class began its first patrol in December 1994. The second submarine, *Victorious,* entered service a year later. The third, *Vigilant,* was launched in October 1995 and entered service in fall 1998. The fourth and final submarine of the class, *Vengeance,* was launched September 19, 1998, at the Marconi-Marine Shipyard in Barrow-in-Furness and commissioned on November 27, 1999. It entered operational service with the First Submarine Squadron, beginning patrols in February 2001. The estimated cost of the production program was $19.8 billion. Each Vanguard-class SSBN has a complement of 205 men, which includes a ship's company of 130 men while on patrol, and carries 16 U.S.-made Trident II (D5) submarine-launched ballistic missiles (SLBMs). The D5s are three-stage, rocket-propelled inertial guidance missiles; they are 44 feet long, 130,000 pounds, and have a range of 4,000 nautical miles. Each missile has a possible maximum of three warheads, for a total of 48 multiple independently targetable reentry vehicles (MIRVs) per submarine. These warheads are a variation of the USN W76 warhead designed for Trident I C4 and Trident II D5 missiles, enclosed in a USN Mk-4 reentry vehicle (RV).

One of the four subs is normally on patrol, and its operations are normally coordinated with those of France's SSBNs. Two others would, in rotation, be in training, in port, or in local waters and could be deployed to patrol positions on relatively short notice. The fourth submarine would be undergoing repair and maintenance and would require significantly longer preparation for deployment. Each SSBN is protected by one or two hunter-killer submarines (SSNs) while en route to and from its patrol area.

The United States and Britain share a pool of SLBMs kept at the Strategic Weapons Facility Atlantic, Kings Bay Submarine Base, Georgia. Although Britain has title to 58 SLBMs, technically it does not own them. A missile deployed on a U.S. Navy SSBN may at a later date be deployed on a British sub, or vice versa. British submarines conduct their missile flight tests at the U.S. Eastern Test Range off the coast of Florida. The *Vanguard* conducted two successful Demonstration and Shakedown Operations (DASO) in May and June 1994, launching two missiles. The *Victorious* fired two missiles during its DASOs in July and August 1995. In October 1997, the *Vigilant* also launched two missiles during two DASOs. On September 21, 2000, the *Vengeance* launched a Trident II D5 during a DASO exercise.

The independent part of Britain's nuclear deterrent is its warhead research and production capability. Warheads are designed at the Atomic Weapons Establishment (AWE) at Aldermaston, a 670-acre site in Berkshire, a county west of London. AWE employs 3,600 people and is managed by an industrial consortium consisting of Lockheed Martin, Serco Limited, and British Nuclear Fuels, which took over in April 2000 under a ten-year, $3.6 billion contract. The component manufacturing facility at Cardiff closed after thirty-six years in February 1997, when its functions were transferred to Aldermaston and Burghfield (a 270-acre site 7 miles to the east). Here, weapons also undergo final assembly, warhead maintenance, and disassembly. Special fissile materials (plutonium and highly enriched uranium) are acquired through the European Atomic Energy Community (EURATOM) Supply Agency (ESA), which maintains safeguards and conducts inspections. (The International Atomic Energy Agency is not responsible for safeguarding European Union (EU) nuclear weapon states other than inspecting selected facilities on a voluntary basis.) On April 1, 1999, the chief of defence logistics, UK, assumed overall responsibility for the routine movement of nuclear weapons within Britain. Day-to-day duties are carried out by the Ministry of Defence Police, with support from AWE civilians and the Royal Marines.

Current Status

In July 1998, the New Labour Party government under Prime Minister Tony Blair announced changes to its nuclear doctrine resulting from the Strategic Defence Review conducted that year. The doctrine states that the ultimate aim of Britain's nuclear forces is to continue to make a unique contribution to ensuring stability and preventing crisis escalation. They also would help guard against any possible reemergence of a strategic scale threat to British security (that is, a threat similar to that presented by the Cold War). In a constantly changing and uncertain world, Britain continues to require a credible and effective minimum nuclear deterrent based on the Trident submarine force in both a strategic and substrategic role. The Royal Navy's Trident force provides an operationally independent strategic and substrategic nuclear capability in support of NATO's strategy of war prevention and serves as the ultimate guarantee of British national security.

Only one Royal Navy SSBN is to patrol at any given time, carrying a maximum load of 48 warheads and assigned to a range of secondary tasks. This submarine patrols at a reduced state of alert, and its missiles are detargeted. It is capable of firing its missiles within several days, not minutes as during the Cold War. Given 4 Trident submarines, if all were fully loaded (MIRVed with three warheads), that would total 192 warheads, with 8 additional warheads for maintenance rotation. This creates a nuclear doctrine that needs to maintain no more than 200 operationally available nuclear warheads. Of these, 100 would be classified as strategic and 100 as tactical. With implementation of these decisions, the total explosive power of Britain's operationally available weapons has been reduced by more than 70 percent since the end of the Cold War. The explosive power of each Trident submarine will be one-third less than that of the Chevaline-armed Polaris submarines, the last of which was retired in 1996.

The Future

A consideration for Britain's future stockpile of operationally deployable nuclear warheads is the "substrategic mission" of the Trident submarine. The substrategic strike mission would be the limited and highly selective use of nuclear weapons in a manner that falls demonstrably short of a strategic strike, but with a sufficient level of violence to convince an aggressor that it would have to halt its aggression and withdraw or face the prospect of taking a devastating strategic strike. This substrategic mission began with *Victorious* and became fully robust when *Vigilant* achieved operational availability on February 1, 1998. This policy means that some Trident II SLBMs have a single warhead instead of the standard three and are assigned targets once covered by Royal Air Force WE177 gravity bombs on Tornado aircraft. Thus, when an SSBN is on patrol, ten, twelve, or fourteen of its missiles may carry as many as three warheads, while the other two, four, or six missiles may be armed with only one. There is thus some flexibility in the choice of yield. For instance, choosing to detonate only the unboosted primary could produce a yield of 1 kiloton or less, choosing to detonate the boosted primary could produce a yield of a few kilotons, and full explosive power would be available through use of both the primary and secondary. Reducing the number of RVs also could extend the range of a missile. In its "substrategic" configuration, a missile carrying a single warhead would have a range of more than 6,000 miles. With dual missions, an SSBN would have approximately 36–44 warheads on board during patrol instead of the maximum complement of 48. Notwithstanding the debate on the number of warheads, the Trident submarine fleet will have a potential in-service operational life until 2026, which could be extended with refits.

—Glen M. Segell

See also: Strategic Forces; Submarine-Launched Ballistic Missiles; Submarines, Nuclear-Powered Ballistic Missile

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Crewmen on board the submarine USS Petrol *lash down a U.S. hydrogen bomb recovered from a depth of 2,500 feet in the Mediterranean Sea 81 days after a B-52 collided with a KC-135 during refueling over Palomares, Spain, in January 1966. (Bettmann/Corbis)*

BROKEN ARROW, BENT SPEAR

Broken Arrow and Bent Spear are U.S. Department of Defense terms used to report accidents involving nuclear weapons or components. Broken Arrow is the flag word for the most serious of these accidents, including: (1) accidental or unauthorized launching, firing, or use of a nuclear-capable weapons system by the United States or a U.S. ally; (2) accidental, unexplained, or unauthorized nuclear detonation; (3) nonnuclear detonation or burning of nuclear weapons or components; (4) radioactive release and contamination; (5) actual or perceived public hazard; and (6) jettisoning of a nuclear weapon or its components.

A Bent Spear is a mishap falling into the following categories: (1) radioactive contamination from the burning, theft, seizure, or destruction of a radioactive limited-life component; (2) evident damage to a nuclear weapon or nuclear component that requires major rework, replacement, examination, or recertification by the U.S. Department of Energy; (3) events requiring immediate action in the interests of nuclear surety or which could result in adverse national and international public reaction or the premature release of information; (4) events indicating that a nuclear weapon or warhead has been armed; and (5) events that could lead to a nuclear weapon system accident and thus warrant the informational interest of, or action by, any of the following agencies in the United States: an appropriate military department or service, the Office of the Assistant to the Secretary of Defense (Nuclear and Chemical and Biological Defense Programs), the Office of the Assistant of Defense (Strategy and Threat Reduction), the Office of the Secretary of Defense (Public Affairs), the Federal Emergency Management Agency.

An example of a Broken Arrow occurred in Goldsboro, North Carolina, in 1961 when two Mk39 nuclear bombs were jettisoned from a B-52. The plane had disintegrated owing to structural failure. Three of the eight crew members were killed in the accident. One bomb parachuted to the ground and was found intact. The other struck the soggy ground of a farm at terminal velocity. The mechanisms designed to prevent detonation worked, and no nuclear blast occurred.

—Zach Becker

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BUILDDOWN

See Arms Control

C

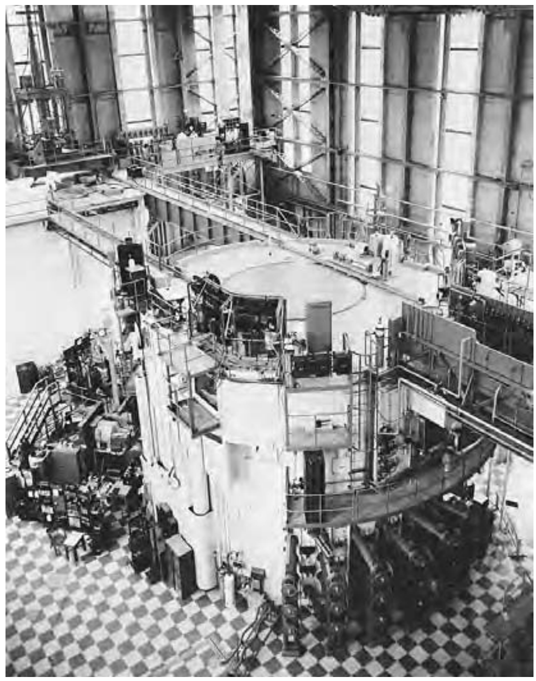
CANADA DEUTERIUM URANIUM (CANDU) REACTOR

The Canada Deuterium Uranium (CANDU) reactor is a pressurized, heavy-water moderated and cooled reactor that uses natural uranium as fuel. All nuclear power reactors in Canada are of the CANDU type. Canada's worldwide marketing has enticed several other countries to produce or coproduce CANDU reactors since the 1970s (*see* Deuterium; Uranium).

An organization of private Canadian industry and government representatives designed the CANDU reactor in the late 1950s. The first CANDU reactor, the Pickering A, Unit 1, began operation in 1971. By 1973, Canada's Pickering A Nuclear Generating Station had four CANDU reactors and led the world in the production of nuclear power.

From the late 1970s to the mid-1980s, Canada built and put into operation nine more CANDU reactors. By the early 1990s, all of the CANDU reactors operational in Canada today were already in commission.

In 1973, India put its first CANDU reactor into service. In the early 1980s, South Korea began operating a CANDU reactor, and it put three more reactors into operation by the end of the 1990s. Argentina began running its CANDU reactor in 1984, and in 1996, Romania began commercial operation of a CANDU reactor. By the summer of 2003, China had two CANDU reactors operational.



The interior for one of the CANDU reactor buildings at the Chalk River project of Atomic Energy of Canada Limited, 1955. (Bettmann/Corbis)

Technical Details

A CANDU reactor uses deuterium to moderate, or slow down, neutrons to thermal energies. Heavy water has a very low absorption cross section for thermal neutrons so there are more neutrons available at the proper energy range to cause fission in the natural uranium fuel (*see* Heavy Water).

Moderating neutrons in heavy water is not as efficient as in regular water because neutrons generally lose less energy per collision with deuterium compared to hydrogen. As a result, the CANDU reactor uses a horizontal cylindrical tank called a "calandria," which contains the moderator at normal pressure. The calandria has a series of pressure tubes that contain the heavy-water coolant at high pressure so that it will not boil away (approximately 10 million Pascal) and it has fuel elements running through it. Because the coolant is pressurized, an extremely large pressure vessel to contain the entire core is not needed.

One important aspect of a CANDU reactor is that it can be refueled at full power. The refueling process involves two machines: one to push the "new" fuel bundle in and the other to receive the "old" bundle as it is being forced out of the assembly. This practice allows for about a 90 percent reactor availability. The movable fuel bundles also allow for increased use of the fissile material.

Current Status

There are currently fifteen CANDU reactors operating in Canada, four in South Korea, two in China, two in Romania, and one each in Argentina and India. India also has ten CANDU copies that it has manufactured based on the original design sold by Canada.

The Advanced CANDU Reactor (ACR) is being developed by Atomic Energy of Canada Limited (AECL) to provide for a smaller reactor core while maintaining a comparable power output. The new design entails the use of higher-pressure steam turbines, light-water instead of heavy-water coolant, and slightly enriched uranium (1.65 percent), which will reduce the amount of fuel needed annually.

—Don Gillich

See also: Reactor Operations

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THE CATHOLIC CHURCH AND NUCLEAR WAR

Officials and scholars working within the Catholic tradition have developed a comprehensive moral critique of nuclear weapons. One of the main purposes of the critique is to nurture a continuing, serious, mutually respectful dialogue on acceptable nuclear policies and practices, not only for the church but for the wider communities in democratic countries. Not surprisingly, there is a great deal of disagreement even within Catholic circles on specific questions, such as first use of nuclear weapons.

The Second Vatican Council declared in December 1965 that any act of war aimed indiscriminately at the destruction of entire cities or extensive areas along with their population is a crime against God and man himself and merits unequivocal and unhesitating condemnation (*Gaudium et spes*). This was the only condemnation issued by the council, which convened in October 1962, the same month that the Cuban missile crisis began.

In the face of the bombing experiences of World War II and the possibility of civilization-threatening nuclear war, Catholic leaders have reaffirmed an absolute prohibition against deliberately targeting civilians while walking a fine line on recognizing the realities of the nuclear age, especially the importance of nuclear deterrence in helping secure a just peace. Some Catholic thinkers have reverted to nuclear pacifism, arguing that the inherent threat to human survival from large-scale nuclear war calls for an absolute moral prohibition on any use of nuclear weapons. Others find nuclear deterrence to be compatible with the just war tradition, when combined with a call for active diplomacy and arms control to reduce, and eventually eliminate, the nuclear threat. Still other Catholic thinkers have championed missile defenses in the hopes that policies of deterrence could be transcended. There are various shades and combinations of the above themes that appear periodically in the literature.

The tension between contrasting views carried over into the three-year effort that, in May 1983, resulted in the American Catholic bishops issuing a much-cited pastoral letter, "The Challenge of Peace." The American bishops again condemned any policy that deliberately targeted noncombatants. They judged nuclear deterrence morally acceptable not as an end in itself but as a stage toward progressive disarmament—a position articulated by Pope John Paul II in his message to the United Nations Special Session on Disarmament in 1982. They also opposed any policy of first use of nuclear weapons. The bishops affirmed this position in 1993 in a new letter, also entitled "The Challenge of Peace."

Catholic thought and debate continues to evolve on these issues as governments adapt nuclear doctrines to the changing conditions of the post–Cold War world.

—Michael Wheeler

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CHALLENGE INSPECTIONS

See Verification

CHELYABINSK-40

Chelyabinsk-40 is also known by its geographic name of Kyshtym or as the Mayak chemical complex. Located near the Chelyabinsk-65 plutonium production facility on the east side of the southern Urals, this site handled waste product storage from five channel-type plutonium production reactors. Construction began in November 1945 and the facility became operational in June 1948. To expedite development of the first Soviet atomic weapons, waste was dumped in Lake Kyzyltash and the Techa River. The radioactive contamination forced twenty-four villages along the Techa River banks to be evacuated, and the river was fenced off to prevent people and livestock from using the water. When radioactivity was discovered downriver in the Arctic Ocean, a waste-processing facility was built.

The separation process used by the Soviets on irradiated fuel elements was an acetate-settling process incorporating nitric acid. The highly radioactive waste solutions produced heat that required the waste holding tanks to be cooled. Following a further extraction process of uranium and plutonium, the remainder of the waste was discharged into lakes and canals in the area.

On September 29, 1957, an explosion occurred in one of the waste tanks, with a force equivalent to between 70 and 100 tons of TNT. The accident was caused by a failure of a cooling pipe in one of the tanks. Cooling fluids began to evaporate, at 350 degrees Celsius, and some 80 metric tons of waste containing 20 million curies of radioactivity were released—about one-third of the amount released in the 1986 Chernobyl accident. In 1967, another calamity struck the area when drought reduced the water level of the lake and gale-force winds spread the radioactive dust throughout 25,000 square kilometers, further irradiating half a million people.

After the 1957 accident, villages were resettled from the surrounding area, but the CIA noticed that on subsequent Soviet maps a large area around Kyshtym was devoid of human settlement. Not until 1989 did the West learn the true extent of pollution and accidents in the area. Kyshtym is now considered one of the most polluted parts of the world, and the radioactive fallout there is considered to have been worse than at Chernobyl.

—Gilles Van Nederveen

See also: Chernobyl; Plutonium; Radiation; Uranium

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CHERNOBYL

Chernobyl is a nuclear power generating station located in Pryp'yat, Ukraine, 10 miles southwest of the city of Chernobyl and 65 miles north of Kiev. The plant contains four reactors, each capable of producing 1,000 megawatts of electric power. The reactors were activated between 1977 and 1983. In 1986, Chernobyl became the site of the worst nuclear power generation disaster in history.

On April 25–26, 1986, a poorly designed experiment led to a chain reaction in the core of Unit 4, causing the reaction to go out of control. Several explosions triggered a huge fireball that blew off the steel and concrete lid of the reactor. The fire in the graphite reactor core led to a partial meltdown of the core and the release of radioactive material into the atmosphere, On April 27, 30,000 residents of Pryp'yat were evacuated. A Swedish monitoring station initially discovered the release. The accident triggered international criticism of Soviet power plant designs and their unsafe operating procedures.

Between 50 and 185 million curies of radionuclides escaped into the atmosphere, several times more than were generated by the Hiroshima and Nagasaki bombs. Windborne radioactive contamination was carried as far away as France and Italy. Reindeer herds in Finland were affected, and millions of acres of forest and farmland were contaminated.

Deformed livestock were born for several years after the accident.

A rapid cleanup led to radioactive material being buried at 800 temporary sites, and the core was encapsulated, but the container was later found to be unsound. Thirty-two people died initially, and dozens of others contracted radiation sickness. It is expected that several thousand radiation-induced illnesses and cancers will develop over time as a result of the worst nuclear accident in history.

Unit 2 remained operating after the accident, but it, too, was shut down following a fire in 1991. Units 1 and 3 remain on line.

The accident sparked renewed interest in the Soviet Union's use of nuclear generating facilities to create weapons-grade nuclear materials. Some commentators blamed the magnitude of the accident on the design's focus on weapon production. The accident led to a reemergence of a strong international antinuclear lobby in a campaign that almost stopped the construction of new nuclear power plants worldwide.

—Frannie Edwards

See also: Graphite; Isotopes; Radiation; Reactor Operations

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CHEYENNE MOUNTAIN, COLORADO

Opened in 1966, Cheyenne Mountain was designed to provide an operations center in the event of a Soviet nuclear attack on North America. Excavation began on May 18, 1961, at a site southwest of Colorado Springs, Colorado. Located under 2,000 feet of the Rocky Mountains, the Cheyenne Mountain Operations Center (CMOC) was ultimately designed to withstand a multimegaton weapon at a range of less than 2 miles. Behind 25-ton blast doors a third of a mile inside the mountain, a steel building complex is mounted on huge steel springs, covering 4.5 acres. Incoming air can pass through a series of chemical/biological/radiological (CBR) filters to remove harmful material, and six backup diesel generators and four water reservoirs allow the

A military shuttle bus exits the entrance to the Cheyenne Mountain Complex, headquarters for North American Aerospace Defense Command, May 11, 2004, in Colorado Springs, Colorado. (Robert Nickelsberg/Getty Images)

CMOC to carry out its mission while cut off from the outside world.

At present, Cheyenne Mountain, known as Cheyenne Mountain Air Force Station (CMAFS), is host to four commands: the North American Aerospace Defense Command (NORAD), the United States Northern Command (USNORTHCOM), the United States Strategic Command (USSTRATCOM), and the Air Force Space Command (AFSPC). The CMOC furnishes both NORAD and USNORTHCOM with a command center for monitoring the internal airspace of Canada and the United States to provide early warning of missile, air, or space threats to North America. Approximately 15 percent of the 210 people who work inside the operations center are Canadian; the remainder are members of the U.S. military. The mission of Cheyenne Mountain has evolved in the face of changing threats. Whereas in the past its focus was on manned bomber attack and intercontinental ballistic missile strikes, it now places greater emphasis on theater ballistic missile warning and support of homeland defense.

—*J. Simon Rofe*

See also: Early Warning; North American Aerospace Defense Command; Surveillance

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CHICKEN, GAME OF

The Game of Chicken, also called a game of right-of-way, has frequently served as a metaphor in studies of escalation scenarios resulting in possible nuclear war. In Chicken, two rational players, A and B, drive toward each other head-on. Each player chooses at the same time whether to swerve (change policy, or "chicken out") or to continue driving straight ahead (maintain the status quo). There are four possible outcomes, A swerves and B continues straight, B swerves and A stays the course, both turn, or finally, neither swerves and there is a collision. Each player does best if he goes straight and his opponent swerves. When solved, this game suggests three likely observed behaviors (equilibria). A swerves and B does not, B swerves and A does not, or both players randomly swerve half the time (resulting in each of the four possible outcomes occurring 25 percent of the time).

In addition to motivating nuclear deterrence literature, the game has three additional implications. First, besides convincing one's adversary that he should swerve, one can "win" by appearing to eliminate one's own ability to swerve. Thus, states in Chicken-like deterrence situations might have incentives to create rigid standard operating procedures for the use of nuclear weapons or take steps to detach their nuclear arsenals from rational control by political authorities, forcing the decision to swerve onto their opponents. Second, if the moves are not simultaneous, but are sequential, the predicted outcomes are quite different, which demonstrates the importance of timing. Third, given the information in the game, one cannot select between the two equilibrium outcomes where one player swerves and the other goes straight. This suggests that the third, more symmetrical outcome, "the mixed strategy," where each side swerves half the time, may be the most likely result, which would mean that 25 percent of the time the players would "collide" in a nuclear war.

—*Scott Sigmund Gartner*

See also: Game Theory

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CHINA SYNDROME

See Reactor Operations

CHINESE NUCLEAR FORCES AND DOCTRINE

China tested its first nuclear device—and became the world's fifth nuclear power—in October 1964. Since that time, China's nuclear stockpile has grown to about 400 weapons—the world's third largest nuclear arsenal. China's nuclear capabilities are concentrated in its roughly 120 land-based missiles under the command of the Second Artillery. Although China's efforts to deploy a submarine-launched ballistic missile (SLBM) have been largely unsuccessful, Western analysts expect China to deploy a new SLBM on a new submarine by about 2010. China's bomber fleet is obsolete, and its air force may no longer have a nuclear role.

Origins of China's Nuclear Weapons Program

China's nuclear program had its origins in a confluence of events that occurred in late 1954 and early 1955. The United States signaled an increasing willingness to rely on nuclear weapons at the close of the Korean War and a desire to incorporate them into its force planning under President Dwight Eisenhower's "New Look" policy. In the fall of 1954, Soviet Premier Nikita Khrushchev rejected Mao Tse-tung's request for Soviet assistance in developing nuclear weapons. On December 2, 1954, in the midst of China's bombardment of the Nationalist-held islands of Quemoy and Matsu in the First Taiwan Straits Crisis, the United States and Taiwan signed a Mutual Defense Treaty—a significant U.S. commitment to the island's defense. That month, U.S. nuclear weapons also were deployed to Okinawa and on the USS *Midway* in the waters around Taiwan. In early January 1955, the chairman of the U.S. Joint Chiefs of Staff publicly suggested that preparations had been made to use nuclear weapons in Asia.

On January 15, 1955, Mao and an enlarged meeting of the Politburo's Central Secretariat decided to proceed with a nuclear weapons program, designated "02." Two days later, the Soviet Union announced it would assist China with peaceful nuclear energy research. The following year, Mao told a meeting of the Chinese Communist Party Central Committee that "now it is time for us to pay attention" to acquiring nuclear weapons (Lewis and Xue Litai 1988, p. 39). By 1958, day-to-day direction of the nuclear weapons program was under the leadership of Vice Premier Nie Rongzhen, who would oversee China's nuclear weapons program for the next thirty years.

The Soviet Union, apparently more willing to cooperate with Beijing in the wake of the 1956 Hungarian uprising, played a key role in China's nuclear weapons program. On October 15, 1957, the countries agreed to the New Defense Technical Accord, in which the Soviet Union promised to supply nuclear weapons design information and even a prototype atomic weapon. The accord collapsed in 1959 and 1960 as the Soviet leadership came to view China as an untrustworthy ally and potentially dangerous adversary and sought to improve relations with the United States. China, however, had already acquired the basis for its own nuclear weapons program.

China's Nuclear Weapons Infrastructure

China's nuclear weapons design and production infrastructure benefited from Soviet guidance until nuclear cooperation was curtailed in June 1959. With the help of Soviet advisers, the Beijing Nuclear Weapons Research Institute, or "Ninth Academy," was established in 1958. Soviet nuclear weapons designers traveled to Beijing in mid-1958 and provided detailed information about nuclear weapon design (based on a 1951 Soviet model)and testing, as well as on organizing a design institute. According to chief designer Yevgeniy Negin, a teaching model and full documentation of the 1951 bomb were ready to be shipped to China—and had been for several months—when they were ordered destroyed by Moscow.

With Soviet help, the Chinese also began construction of several nuclear weapons–related production facilities. The key enterprises were:

- The Baotou Nuclear Fuel Component Plant (Plant 202), which began operation in 1962 and produces uranium tetrafluoride (UF_4), uranium fuel rods for the Jiuquan facility, and lithium-6 and tritium for thermonuclear weapons;
- The Lanzhou Gaseous Diffusion Plant (Plant 504), which was started in 1958 and produced its first highly enriched uranium (HEU) on January 14, 1964;
- The Jiuquan Atomic Energy Complex (Plant 404), including a plutonium production plant that became operational in 1966 and a plutonium reprocessing plant that became operational in 1970.

While the Chinese pursued both an HEU and plutonium program, the former was significantly more advanced when Soviet aid was cut off.

In 1962, the Beijing Nuclear Weapons Research Institute was closed and its design work shifted to the newly established Northwest Nuclear Weapons Research Institute, also known as Plant 221, in Haiyan, Qinghai province. According to one Chinese report, "sixteen nuclear weapons were invented" at Plant 221 before it closed in 1987.

As part of Mao's "Third Line" program that emerged in the late 1960s, duplicates of these enterprises were built in China's interior, where they were believed to be less vulnerable to Soviet or

American attack. China's nuclear design work shifted from Haiyan to the China Academy of Engineering Physics (CAEP), located in Mianyang, by the early 1970s. The plutonium production and processing facilities at the Baotou Nuclear Fuel Component Plant were mirrored in the Yibin Nuclear Fuel Component Plant, and the gaseous diffusion uranium enrichment facilities at Lanzhou Gaseous Diffusion Plant were replicated at the Heping Nuclear Fuel Complex. Plutonium production and separation facilities at the Jiuquan Atomic Energy Complex (Gansu) were duplicated at Guangyuan (Plant 821).

China reportedly halted uranium enrichment for military purposes in 1987, and production of plutonium for weapons in 1991, although it has not officially announced either change in policy. Although nuclear weapons–related work continues at CAEP, China's signing of the Comprehensive Test Ban Treaty in 1996 and its moratorium on nuclear testing severely limit the development of new nuclear weapons.

Production and presumably maintenance of the existing stockpile reportedly takes place at the China National Nuclear Corporation's Special Parts Factory (or Factory 903) in Sichuan.

Nuclear Weapons Design and Testing

Ninth Academy Director Li Jue had overall responsibility for the research, development, and design of China's fission and fusion warheads in the 1950s and 1960s and led the design of China's first nuclear weapon. His team designed and assembled China's first atomic weapons at Plant 221. China's first nuclear test, an HEU implosion device, took place on October 16, 1964, with a yield of about 22 kilotons.

Even before the first nuclear explosive test, China's leaders directed the Ninth Academy's design team to begin work on a thermonuclear weapon. In February 1967, the design was completed. The device was tested on June 17, 1967, and had a yield estimated at 3 megatons.

Between its first test in 1964 and its announcement of a moratorium on nuclear testing in July 1996, China completed forty-five nuclear explosive tests. These included a test of a "neutron" warhead in 1988, based on a breakthrough made in 1984, and reportedly a test of a "miniaturized" warhead in 1992. The latter capability led to charges—vehemently denied by Chinese scientists—that Beijing had gained access to U.S. nuclear secrets through espionage.

China does not reveal information about its nuclear weapons stockpile. The Natural Resources Defense Council (NRDC) estimates that China has produced about 750 nuclear weapons over the life of the program and that China's nuclear weapon stockpile reached 75 nuclear weapons by 1970; 185 by 1975; 280 in 1980; 425 in 1985; and 430 in 1990. NRDC further estimates that China has maintained a force of about 400 weapons, including 150 tactical nuclear warheads, since 1994, but cautions that these estimates "are probably not accurate to better than 50 percent, due to the uncertainty in the number of tactical warheads." China clearly has the ability to produce tactical nuclear weapons, but there is no confirmation that it has produced or deployed them.

Ballistic Missiles

In early 1956, Qian Xuesen, an American-trained jet propulsion expert who had returned to China the year before, was appointed director of the country's new "Fifth Academy," the entity charged with developing China's missile and rocket capability. Chinese engineers were able to work with two R-1 (the SS-1, a Soviet version of the German V-2) and two R-2 (SS-2) missiles, provided by the Soviet Union in 1956 and 1957. When the U.S.S.R. withdrew its assistance, Chinese scientists continued their work and successfully tested a Chinese version of the R-2, the DF-1 (Dongfeng-1, or East Wind–1) in November 1960.

By 1965, the Fifth Academy was able to formally propose a program to design and build four different missiles over the next eight years. These would become the DF-2 (for which research and development [R&D] actually began in 1960), the DF-3 (R&D initiated in 1964), the DF-4 (R&D initiated in 1965), and the DF-5 (R&D also began in 1965).

The DF-2 (Western designation: CSS-1) and its longer-range variant, the DF-2A, were deployed from the late 1960s until 1978. With a range of 1,050 km (1250 km for the 2A), the DF-2 "medium-short-range missile" was reportedly designed to reach Japan carrying a relatively low-yield (12- to 20-kiloton) warhead.

The DF-3/CSS-2, deployed since 1970 or 1971, is a road-transportable medium-range ballistic missile capable of being launched from permanent pads or portable stands. Designed originally to reach U.S. bases in the Philippines, the DF-3 has a range of up to 2,650 km (up to 2,800 km for the longer-range version, the DF-3A) and carries a single 3.3-megaton warhead. It has reportedly been deployed at Tonghua, Jianshui, Kunming, Yidu, Dengshahe, and Lianxiwang and is being phased out in favor of the DF-21/CSS-5.

The DF-4/CSS-3 intercontinental ballistic missile (ICBM), deployed since 1980, also carries a single 3.3-megaton warhead but has a range of up to 7,000 km. The missile is deployed in two launch configurations: a roll-out-to-launch site and an elevate-to-launch silo. Reportedly intended originally to reach U.S. bases in Guam, its range was extended to reach Moscow in the wake of Sino-Soviet border clashes in 1969. The dozen DF-4s that are currently deployed are "almost certainly intended as a retaliatory deterrent against targets in Russian and Asia" (National Intelligence Council, p. 8). The DF-4 has reportedly been deployed at Da Qaidam, Delingha, Sundian, Tongdao, and Xiao Qaidam.

The DF-5/CSS-4 ICBM, designed to reach the continental United States, also was first deployed as early as 1980. The silo-based missile has a range of up to 12,000 km and carries a single 4- to 5-megaton warhead; the DF-5A, replacing the DF-5, is reported to have a 13,000-km range. Between eighteen and twenty DF-5s are deployed with the Second Artillery, and most (one press report, citing a "leaked" document, indicated thirteen) are believed to target major U.S. cities. DF-5s are reportedly deployed at Luoning, Xuanhua, and Jiuquan.

The DF-21/CSS-5, a land-mobile solid-fueled medium-range ballistic missile (MRBM), was based on the JL-1 SLBM. It has been deployed since about 1985, replacing the liquid-fueled DF-3. The DF-21, with a range of 1,800 km, carries a single 200- to 300-kiloton warhead. Forty-eight DF-21s and DF-21As (its longer-range variant) are reportedly deployed at Tonghua, Chuxiong, Datong, Lianxiwang, and Jianshui. Like the DF-3, these are presumably intended for targets in Russia and Asia. A model with a conventional warhead variant is reportedly under development.

China probably maintains its land-based missiles in an unfueled status and without their nuclear warheads. It would likely take several hours to prepare them for launch. Chinese designers long ago recognized that such land-based, fixed-site missiles would be increasingly vulnerable to enemy preemption. In 1975, they experimented with rail-mobile basing for the DF-4. Three years later, Deng Xiaoping emphasized that he was most interested in mobility on land; that is, the use of modern weapons to fight guerrilla war, and soon after, the state committee overseeing missile development indicated that "to fight a modern guerilla war, the second generation strategic ballistic missiles must be mobile, rapid [in preparation time], and concealable, with mobility as the focus" (Lewis and Xue Litai 1988, p. 26).

This focus on increasing mobility and reaction time led the Chinese designers to develop the DF-21/CSS-5 from the JL-1/CSS-N-3, a submarine-launched ballistic missile (SLBM) with a range of 1,700 km that had been under development since 1967. The Chinese Navy had little success integrating the SLBM, which carries a 200- to 300-kiloton warhead, into the Type 092 (Xia) submarine, based at the North Sea Fleet's Jianggezhuang submarine base. The Xia, launched in 1981, has had a spotty record, spending years in overhaul, and was considered "nonoperational" for many years. Its current status is unclear.

Since 1986, the Chinese also have been developing the land-mobile DF-31 intermediate-range ballistic missile (IRBM) and its seagoing sibling, the JL-2 SLBM. The DF-31, which received priority over the JL-2 in development, is expected to begin deployment by 2005. The JL-2 is expected to be deployed by 2010 on a new submarine, the type 094, currently under development. The Chinese also have been developing a 12,000-km-range variant of the DF-31, the DF-31A, capable of reaching the entire continental United States.

In addition to these strategic missiles, China deploys two conventionally armed short-range ballistic missiles (SRBMs), the DF-15/CSS-6 and DF-11/CSS-7, opposite Taiwan. As of 2004, China reportedly had about 500 of these SRBMs and their variants deployed, and it is adding about 75 per year.

China's ballistic missiles, like its nuclear weapons, were developed by teams of specialists. The first generation of ballistic missile designers responsible for the DF-2 and DF-3 included chief designer Xie Guangxuan, The chief-designer system collapsed during the Cultural Revolution but was reinstated in the late 1970s.

Although dozens of factories are involved in producing key components for China's ballistic missiles, Nanyuan's Factory 211 (also known as the Capital Aerospace Machinery Company) is generally responsible for assembling liquid-fueled ballistic missiles. The Nanjing Factory 307 (the Nanjing Chenguang Machine Factory) is generally responsible for solid-fueled strategic missile production. China's CSS-6 SRBM was reportedly designed and produced by the China Aerospace Corporation's Academy of Launch Technology (CALT—the current name of the original Fifth Academy). The CSS-7 SRBM was reportedly designed at the 066 Base (the Sanjiang Space Group) and is produced at a Sanjiang factory in Yuan'an.

In 1966, China established the Second Artillery to control its new land-based missile forces. It is reportedly organized into six "bases" (at Shenyang, Huangshan, Kunming, Luoyang, Huaihua, and Xining. Each base oversees a number of launch brigades with one missile type, consisting of up to four launch battalions. As of 2003, the Second Artillery's force structure reportedly comprised fewer than 50 DF-3/CSS-2s; about a dozen DF-4/CSS-3s; about 20 DF-5/CSS-4s; about 48 DF-21/CSS-5s; and about 450 CSS-6s and CSS-7s.

Bombers

China's first bombers were the Hong-5, a 1950s copy of the Soviet Il-28 Beagle, and the Hong-6, a licensed copy of the Soviet Tu-16 Badger produced in Xi'an. Some of the Nanchang Q-5 attack aircraft, based on the MiG-19, also may have had a nuclear role. However, China's commitment to a nuclear bomber capability is increasingly uncertain: Its 2002 White Paper on National Defense notes a nuclear mission for the Second Artillery and the navy but none for the air force. The air force's new bomber, the Xi'an JH-7 (or FB-7), is not believed to have a nuclear mission. The U.S. Department of Defense Annual Reports on the military power of the People's Republic of China do not mention a nuclear bomber capability (*see* Bombers, Russian and Chinese Nuclear-Capable).

Chinese Strategic Thought

Since the beginning of nuclear weapons development in China, two main ideas have influenced Chinese nuclear policy: first, dedication to building a small, high-quality force, and second, commitment to a no-first-use policy. Mao laid the groundwork for the first principle in the early days of the program when he indicated that China should build a few high-quality nuclear weapons. China's no-first-use pledge was made the day of its first nuclear test, when Beijing stated, "At any time and under any situation, China will not use nuclear weapons first" (http://www.nit.org/db/china/engdocs/zhu0297.htm). These two pillars of Chinese nuclear planning continue to have a profound influence on Chinese strategy. If the key components of nuclear strategy are timing and targeting, a commitment to a small force and a no-first-use posture severely constrains China's strategic options—and helps control spending.

As a result, China has apparently adopted a strategy—and force structure—based on riding out an attack and retaliating by targeting large, soft targets, including cities and industrial and military targets. Western and Chinese authors have characterized this strategy as one of "minimum deterrence." Such a posture, however, cannot be sustained if China's small force becomes vulnerable, either to preemption on the ground or to missile defenses. China is clearly shifting to more survivable mobile forces and away from its fixed site forces. But there also continues to be an extensive internal discussion—and advocacy—of a shift to a "limited deterrent." While the logic underpinning a minimal deterrent is an emphasis on inflicting unacceptable pain on an attacker, a limited deterrent is intended to undermine the enemy's military capabilities by striking militarily significant targets.

For the foreseeable future, a minimum deterrent may be the only realistic—and desirable—option for China vis-à-vis the continental United States. But a limited deterrent may be more realistic against regional adversaries or U.S. forces based in Asia. Western experts increasingly distinguish between China's minimum strategic deterrent, directed at the United States and Russia, a limited deterrent for regional adversaries, and a warfighting strategy for its conventional SRBM force.

—Peter Almquist

See also: Negative Security Assurances; Strategic Forces; Submarine-Launched Ballistic Missiles; Submarines, Nuclear-Powered Ballistic Missile

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CIRCULAR ERROR PROBABLE

See Accuracy

CITY AVOIDANCE

The term "city avoidance" refers to a nuclear policy decision to target another state's military forces or industry rather than its population centers. Targeting policy has always been a contentious issue in warfare. With the advent of nuclear weapons, the potential damage that could be inflicted upon a city became very real, and throughout the Cold War there were debates about whether population centers or solely military targets should be emphasized in defense planning.

The issue of city avoidance came to prominence in the early 1960s. The John F. Kennedy administration inherited a single plan that called for launching many nuclear weapons at once without regard for the increasing Sino-Soviet split. Under U.S. Secretary of Defense Robert McNamara, the United States developed a series of nuclear options that sought to establish and maintain a ladder of escalation. These became known as Single Integrated Operational Plan 62 (SIOP-62). McNamara articulated this new policy in 1962 in a speech at Ann Arbor, Michigan, in which he sought to encourage the avoidance of city targeting.

If population centers were to be avoided, however, the obvious alternate target became an opponent's strategic nuclear forces. Since there was little point targeting an opponent's strategic forces after they had been launched, city avoidance strategies became associated with counterforce strategies. Thus, from the 1960s until the end of the Cold war, debate raged over targeting options, especially over which strategies would best preserve deterrence and maintain the peace.

—Andrew M. Dorman

See also: Counterforce Targeting; Countervalue Targeting

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CIVIL DEFENSE

Civil defense is the passive protection of a population against damage or casualties resulting from a strategic attack. Debate over the requirement for some form of defense has surrounded nuclear weapons almost from their inception. The debate about civil defense has focused on two issues. First, there has been the question of balance between offensive and defensive measures. In other words, given finite resources, what share of expenditure should civil defense have compared to a nuclear weapons program? What is the most appropriate balance for the state, given the potential scale of physical and societal damage that a nuclear attack could inflict? Second, what is the minimum requirement for civil defense capability? In other words, what is the minimum requirement for the preservation of some form of civilian administration for the survivors of a nuclear attack?

Although this debate was largely a Cold War phenomenon, recent events have led to new assessments of the proper balance between offensive forces and civil defense measures. The attacks of

September 11, 2001, on the United States, the earlier use of chemical weapons on the Tokyo underground, and the increasing proliferation of knowledge about weapons of mass destruction and weapons of mass effect have led a revival of the civil defense debate. This has now been couched in the terms of societal resilience and the protection of critical infrastructure.

Defining civil defense today thus creates an interesting challenge. At its broadest, it refers to all elements that are designed to protect the state from the effects of attack rather than merely its armed forces. In the Cold War, this would have included elements such as shelters for all or part of the civilian population. It incorporated the stockpiling of material and equipment that would help preserve society. It also might have included more active elements of defense, such as an air defense system and ballistic missile defenses. Since the end of the Cold War, the debate has shifted toward the protection of critical infrastructure and large-scale disaster management. Such a definition now incorporates counterterrorism forces and the ability to maintain the continuity of supply for critical elements such as food, water, and fuel supplies to civil society.

History and Background

Throughout the evolution of warfare, technological breakthroughs have been rapidly countered as advantage swung between the offense and defense. The images many Americans have of World War I are about the success of the defense, with trenches and machine guns inflicting mass casualties on the attacking side. It was the advent of the airplane and its ability to carry bombs beyond the battlefield, however, that led to interest in civil defense. Although World War I witnessed the bombing of some cities, these air attacks were limited. Between the wars, advocates of airpower, such as military theorists Guilio Douhet, Billy Mitchell, and Hugh Trenchard, advocated the bombing of strategic targets, including cities, as a means of avoiding trench warfare. Concern was expressed by many that cities might be targeted with gas bombs and conventional munitions, leading to hundreds of thousands of casualties and the breakdown of society. By the outbreak of World War II, a number of states had quite significant civil defense programs as a means of limiting the impact of potential air raids. In the United Kingdom, for example, there was a wide-scale distribution of gas masks, a major program to provide underground shelters in towns and cities, and the mass evacuation of significant numbers of children and their teachers to the countryside for much of the war.

It was hardly surprising, then, that as soon as the first atomic bomb was dropped on Hiroshima, the issue of potential defenses against atomic attack was discussed. Initially, debate centered on whether a radiation antidote could be developed. While studies continued in this area, other active and passive measures were examined, such as the dispersion of key assets and increased protection. These ideas were reviewed and adopted in varying levels by different cities and states. Because early atomic bombs were large and carried by bomber aircraft, both sides of the superpower standoff developed air defenses to protect themselves. With the advent of the hydrogen bomb and ballistic missiles capable of carrying thermonuclear warheads, active defenses in general were increasingly reduced in scale in the West, although the Soviet Union maintained a considerable defensive capability. This difference in approach reflected differences in the strategic nuclear forces of the two nations. The Soviets, for example, had only a relatively small bomber force and relied almost entirely upon submarine and land-based ballistic missiles. It also reflected differences in outlook about the utility of defenses that existed between Soviet and U.S. officials.

The advent of ballistic missiles saw the offense-defense cycle come full circle. As both sides developed intercontinental ballistic missiles (ICBMs), the Soviet Union and United States each sought to develop an antiballistic missile system. Developments in their respective programs were limited by the Anti-Ballistic Missile Treaty (1972). Until recently, only the Soviet Union (and now Russia) had deployed an active defense with an antiballistic missile system. The Gerald Ford administration decided to scrap the Sentinel/Safeguard system in the mid-1970s. In 1983, however, President Ronald Reagan launched the Strategic Defense Initiative (SDI), which sought to create an active defensive screen. This would have been undertaken in conjunction with an air defense initiative to provide complete protection for the United States from air and missile attack. This program has been modified over the decades since Reagan's term in office but in a more modest form is scheduled for deployment beginning in 2004 (*see* Anti-Ballistic Missile [ABM] Treaty; Safeguard Antiballistic Missile (ABM) System; Sentinel Anti-Ballistic Missile System; Strategic Defense Initiative [SDI]).

Several different approaches to passive defense were also undertaken. Passive measures included the dispersion of key targets and encasing them, where possible, in reinforced concrete to protect them from the effects of nuclear blast. Protection against nuclear fallout required carefully constructed filtration systems and the ability to be self-sustaining for some time (estimates varied between a few days and several months), which necessitated the accumulation and preservation of considerable stockpiles of foodstuffs and other materials. Many commentators believed that such measures were impracticable in Europe and the United States, where population densities were too great and societies too vulnerable. To survive in such an apocalyptic future, a society would have to become cellular, consisting of independent, self-sustaining units. It would require a significant program of shelter construction and a devolved, autocratic system of government in wartime. This seemed to run counter to many Western values, and critics suggested that such a program was merely delusionary and very expensive. Nevertheless, in the United States the question of civil defense ebbed and flowed as a subject of debate with no all-encompassing program ever being fully enacted. Instead, more active forms of defense tended to receive investment, such as the Sentinel program, the Strategic Defense Initiative, and the National Missile Defense program.

Other Western governments adopted a policy of universal provision of civil defense, seeking to protect their societies through active civil defense programs, with a focus on passive measures. In Sweden and Switzerland, the goal was to provide sufficient shelters for the entire population. In the Swiss case, this included the preservation of a significant infrastructure to support Swiss society. Similarly, Israel undertook a significant civil defense program, which it was able to utilize during the 1991 Gulf War when concerns were expressed about the potential use of weapons of mass destruction by Iraq. The Soviet Union also engaged in a significant civil defense program, but this could not match the capabilities of the Swiss program. A number of analysts argued that this program, when matched to a first-strike capability, was destabilizing because it ran counter to the principle of assured destruction. At issue was the amount of damage that a state could sustain and still survive. As a comparative measure, the damage wreaked on Germany by the Allied strategic bomber offensive of World War II was equivalent to more than 400 Hiroshima-size atomic bombs. The costs associated with such defenses and concern about their relative value meant that for most states, few defenses were adopted. Deterrence, rather than defense, was seen as the more affordable option, especially if that deterrent was provided by another state.

The Future of Civil Defense

With the end of the Cold War, civil defense has shifted in focus away from preparations to counter a devastating attack by one state upon another. Now, planners focus their attention on managing the effects of catastrophic terrorism from a weapon of mass destruction or from a conventional bomb attached to some nuclear material in some form in a so-called "dirty bomb." During the Cold War, analysts were greatly concerned about the physical damage nuclear weapons could wreak on society. The "dirty bomb" raises the question about radioactive contamination of key industrial, commercial, or cultural sites. For example, the use of such a device in London or New York could have a devastating impact upon the economy of not just the target states but also the wider world. Western economic systems are based on a small number of centralized stock markets, so a disturbance in one of them could potentially be quite catastrophic. Nevertheless, globalization and the shift to the information age has enabled increased resilience as companies and governments can create back-up facilities quite quickly.

—Andrew M. Dorman

See also: Radiological Dispersal Device; Peacekeeper Missile; Submarine Launched Ballistic Missile

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COLD LAUNCH

Cold launch is a technical innovation that allows a missile to be ejected from its silo or missile tube by a gas generator or mortar charge. The first-stage missile motor ignites after the missile has cleared the silo or launch tube. The Soviet intercontinental ballistic missiles (ICBMs) SS-11, SS-17, and SS-18 were all cold-launched, and throughout the Cold War U.S. officials believed that these silos could be quickly reloaded with ICBMs in a nuclear conflict. But it now appears that the Soviets had to adopt the cold-launch technique to limit the heat and acoustical stresses on their third-generation ICBMs. This allowed Soviet missile designers to use reconditioned silos for the new ICBM designs without having to expand them.

The Soviet Union initially used gas generators to eject the ICBMs, but mobile fourth-generation ICBMs such as the SS-25 and SS-27 are ejected by means of a mortar charge in the launch tube within the transporter-erector-launcher.

Submarine-launched missiles also must be cold-launched because they have to be ejected from a submarine-based tube and pushed to the surface of the ocean before the first-stage motor can ignite. The cold launch method increases the payload capability by approximately10 percent and prevents costly rebuilding to the launch silo.

The MX Peacekeeper was the first U.S. ICBM to use cold-launch technology. The missile was placed inside a canister and loaded into the launch facility. When launched, high-pressure steam ejected the canister from the launch silo to an altitude of 150 to 300 feet, and once the missile cleared the silo, the first stage ignited and sent the missile on its course. This technique allowed Strategic Air Command to launch the Peacekeeper from Minuteman silos despite the fact that the Peacekeeper was three times larger than the Minuteman III.

—*Gilles Van Nederveen*

See also: Launchers

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COLD WAR

"Cold War" refers to the political, ideological, and strategic standoff between the United States and the Soviet Union that emerged from the destruction of World War II, and which ostensibly ended with the disappearance of the Soviet Union in 1991. It was a "cold" war because it never took the form of direct military confrontation between the two superpowers, although many Soviets and Americans died at each others' hands in the proxy wars and clandestine operations that characterized the second half of the twentieth century. It was "war," rather than "competition," because it involved mutually irreconcilable strategic objectives. Each side prepared to engage in "hot" war if its own strategic position or vital national interests were threatened by its opponent.

In the view of most observers, what kept the Cold War "cold" was the terrifying prospect of a full-scale nuclear exchange. Throughout the Cold War, both U.S. and Soviet officials and military planners presumed that direct military hostilities between the superpowers could lead to nuclear escalation that might culminate in Armageddon. Given the crises that punctuated some forty-five years of Cold War, it is easy to imagine, in the absence of nuclear weapons, both superpowers resorting to military force, generally on someone else's territory. The undeniable fact of nuclear weapons, however, virtually guaranteed unacceptable destruction on the territory of the superpowers, once direct warfare began. There was never a point when the political objectives to be gained justified the self-destruction that would likely result from escalation to nuclear weapons.

There are those who argue that the *real* political objectives of the superpowers—rather than the objectives presumed by the opposing superpower—were never so irreconcilable as they seemed, and that, as a result, the Cold War was unnecessary—a conflict produced by miscalculation, mistrust, and the security dilemma. Once started, the Cold War took on a life of its own as both parties created institutions; policy communities that had a vested interest in fulfilling their part of the superpower standoff.

There is no agreement about either the exact beginning or the end of the Cold War. There was no military attack or declaration of war to mark its beginning, yet most scholars note that the Soviet-American wartime alliance had deteriorated beyond repair by 1947. There was no clear demarcation between the "prelude to war" and war itself, although many point to speeches and policies—generally in 1946 or 1947, sometimes earlier—that seem to be the moral equivalent of a declaration of Cold War.

A U.S. P-3 Orion overflies a Soviet guided missile cruiser during the Cold War. (Corbis)

Likewise, there was no "peace treaty" to signify the end of the war. Victory for the West came as a result of the Soviet Union's disappearance or transformation as a political entity, which occurred on Christmas Day, 1991. Yet, even the selection of this date is somewhat arbitrary; the political transformation of the Soviet Union had already been under way for some time, and some believe that the political competition between the United States and Russia has survived the end of the Cold War.

The nature of the Cold War changed often during the nearly half century that it lasted. The level of hostility and cooperation between the superpowers varied. There was a certain rhythm as successive Soviet and American political leaders consolidated their own positions, probed for weaknesses in the other side, discovered their own vulnerabilities, and occasionally sought to escape from the intractable dynamics of the conflict. Even during the most hostile periods of the Cold War, the United States and the Soviet Union shared a fairly common understanding of the logic and character of nuclear weapons and their effect on their relationship.

The Origins of the Cold War

There was never a time during the seventy-four-year existence of the Soviet Union in which it enjoyed "good" relations with the United States. Even in its early years, when the Soviet Union could not directly threaten the United States, American policymakers were suspicious of Bolshevism, which was viewed as dangerous. Although the Soviet Union had conspired with Nazi Germany to attack Poland in September 1939, the Nazi surprise attack on the Soviet Union in June 1941—almost six months prior to Japan's attack on Pearl Harbor—made the Soviets a de facto ally of the United States. U.S. officials had little sympathy for Joseph Stalin's regime, but Nazi conquest of the Soviet Union was unacceptable. U.S. material assistance in the form of food and war materiel helped keep the Soviet Union in the war. The Soviets tied down the bulk of the German military while the Allies prepared a "second front" in Europe and liberated Western Europe.

From the Soviet perspective, Allied delays opening a second front in Europe reinforced Stalin's distrust of the West, which he feared might make common cause with the Nazis to destroy Soviet communism. With their backs against the wall in 1942, the Soviets demanded an Allied counteroffensive, but they were disappointed when it materialized only in North Africa and, in 1943, in Italy. By the summer of 1943, however, Soviet victory over the Nazis seemed assured as the Red Army began to push west. To Stalin, the Allies' delay in opening a second front only proved that they were quite content to let the Russians bear the brunt of fighting the Nazis. Moreover, to Stalin, the urgency with which the Allies finally did mobilize to attack Normandy in June 1944 simply reflected their realization that the Red Army was poised to march alone through Eastern Europe and into Berlin.

As wartime allies, the United States and the Soviet Union were wary of each other's strategic intentions. By the end of the war, Soviet military and political domination of Eastern Europe was a fait accompli, and Stalin was determined to ensure that an attack from the capitalist West would have to fight its way through a significant buffer zone before reaching Soviet territory. Within the U.S. political leadership, the end of the war witnessed a debate about whether inducements could mobilize the Soviet Union to play a cooperative role in ensuring postwar security, rebuilding destroyed economies, and reconstructing former adversaries. By 1946, it was increasingly clear to U.S. policymakers that the prospect of political and economic aid would not alter these Soviet strategic interests, and that it would be counterproductive to accommodate Soviet concerns. As early as February 1946, U.S. Secretary of State James F. Byrnes spoke of a "get tough with Russia" policy, which was soon followed by Winston Churchill's "Iron Curtain" speech. In 1947, this perspective became a policy—"containment"—which became U.S. strategy for the rest of the Cold War.

The Cold War Hardens, 1947–1957

Cause and effect are intertwined in the immediate postwar period, but a series of moves and countermoves inexorably hardened the division in both Europe and Asia. The Truman Doctrine (1947) and the Marshall Plan (1948) were designed to counter Communist advances; successive Eastern European states became Communist; and the Soviets tried to blockade West Berlin (1948) to force the Western powers to reach a political settlement on the future of Germany. The Western European Union's Brussels Treaty (1948) preceded—by design—formation of the North Atlantic Treaty Organization (NATO, 1949). The front lines of the Cold War became represented by divided states in Korea (1948), Germany (1949), China (1949), and Vietnam (1954).

The U.S. response to the Chinese Communist victory, and especially to the Soviet Union's development of a nuclear capability, both of which occurred in 1949, was a comprehensive reappraisal of America's strategic position. The document summarizing this reappraisal, National Security Council Document 68 (NSC-68), concluded that the Soviet Union sought world domination and redefined containment in military terms, calling for U.S. development of thermonuclear weapons and a greater capability to fight conventional wars wherever Communist aggression would occur. The Korean War, which began in June 1950, confirmed many of the dire predictions offered by NSC-68, leading Congress and President Harry S. Truman to endorse its political and programmatic recommendations.

The Korean armistice in July 1953 ended a "hot battle" in the Cold War, but without offering a solution to the problem of a divided Korea, a problem that has endured well beyond the demise of the Soviet Union. The new Dwight D. Eisenhower administration, however, had campaigned on the platform that "hot wars"—especially in Asia—played into the hands of the Communists. With Stalin dead and a new leadership jockeying for position in Moscow, Eisenhower decided that reliance on nuclear deterrence—which was governed by a "New Look" in procurement policy and the declaratory policy of "massive retaliation"—was a more affordable and therefore more sustainable strategy for what was clearly going to be a protracted strategic standoff (*see* Massive Retaliation; New Look). Under U.S. Secretary of State John Foster Dulles, the United States proceeded to expand or establish alliances around the periphery of the Soviet Union. These efforts resulted in NATO (with the Federal Republic of Germany as an armed partner, and later Greece and Turkey), the Southeast Asia Treaty Organization (SEATO), the Baghdad Pact (with the UK, Iran, Iraq, and Turkey), the ANZUS (with Australia and New Zealand) Pact, and bilateral agreements with numerous other states, including Japan, the Republic of Korea, and Taiwan.

Alliances bring their own complications. As NATO's military capabilities in Western Europe grew, including deployment of tactical nuclear weapons to stop any Soviet military advances, some of America's NATO allies began to question the desirability of reliance on nuclear deterrence. In a much-publicized war game conducted in June 1955 called Carte Blanche, NATO simulated the "limited" use of tactical nuclear weapons, most of which necessarily were targeted on German territory. According to game results, more than 1.5 million Germans would have been killed and some 3.5 million incapacitated in a real event of this type. This poignant reminder of the dilemmas of the nuclear age left many wondering whether the defense of Europe might mean its destruction. In subsequent years, however, attempts to reduce reliance on nuclear weapons in the defense of Europe brought opposite protests. Any reduction was thought to signal Washington's reluctance to fulfill its deterrent threats and its understandable preference for keeping the destruction of war confined to a European battlefield. As the nuclear age unfolded and the United States became increasingly vulnerable to direct attack, sustaining the credibility of its nuclear deterrent guarantee to NATO became problematic (*see* Missile Gap).

Brinkmanship, 1957–1962

On November 17, 1956, Soviet leader Nikita Khrushchev threatened to "bury" the West. In 1957, there were growing concerns that he just might succeed. In August, Moscow announced its first test of an intercontinental ballistic missile, and six weeks later it launched Sputnik, the first satellite to orbit the earth. Following Sputnik, U.S. officials began to worry that the United States no longer led the Soviet Union in the nuclear arms race and that it was becoming vulnerable to massive nuclear attack by ballistic missiles. Eisenhower's memoirs speak of trying to calm "mass hysteria" in American public opinion as the 1957 Gaither Committee and the 1957 and 1958 Rockefeller reports warned of a significant American strategic vulnerability.

Within a year of Sputnik, Khrushchev declared the first of three ultimatums in an attempt to get the West out of Berlin. Although none of these challenges succeeded, each brought an additional increment of military and political tension, with U.S. and Soviet tanks eventually facing each other across checkpoints in Berlin. During this same period, relations alternated between threat-induced crises and periods of thaw. During the latter, Khrushchev visited the United States and the first U.S.-Soviet arms control treaty was signed (Antarctic Treaty). There were moratoriums on nuclear testing, but there were also boasts of Soviet tests in excess of 50 megatons. The so-called "Spirit of Camp David," however, reached an abrupt end when an American U-2 was shot down during a reconnaissance flight over Soviet territory in May 1960.

By the time John F. Kennedy was elected president in November 1960, U.S.-Soviet relations were growing highly unstable and unpredictable. In their first summit meeting in Vienna in June 1961, Khrushchev badgered Kennedy in an attempt to test the young president's resolve following the U.S. disaster at Cuba's Bay of Pigs. Two months later, the Berlin Wall went up. Fourteen months after that, Khrushchev tested the United States again by placing nuclear-armed intermediate- and medium-range ballistic missiles in Cuba.

The Cuban missile crisis was the closest that the United States and the Soviet Union ever came to nuclear war. Both Kennedy and Khrushchev realized after the crisis that they had come dangerously close to war and undertook a series of initiatives to reduce some of the precarious aspects of the Cold War. Within a year of the crisis, a "Hot Line," a direct teletype link to facilitate communication in a crisis, was in place between Washington and Moscow. The United States and the Soviet Union also concluded a Limited Test Ban Treaty in 1963 to bar nuclear tests except those conducted underground (*see* Cuban Missile Crisis; Limited Test Ban Treaty [LTBT]).

Prelude to Détente, 1964–1968

During the mid-1960s, both the United States and the Soviet Union discovered several common interests, leading them to explore additional means of managing their conflict and controlling the nuclear technology that formed the unavoidable backdrop to their relationship. First, the brinkmanship of the Cuban missile crisis mobilized both sides to explore mechanisms to inject greater stability into the relationship. Maturation of the missile age—by this time, both intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles (SLBMs) were entering respective inventories—enabled both superpowers to begin protecting their own forces in hardened underground silos and command centers and to move away from vulnera-

President Kennedy meets with U.S. Army officials in Florida during the Cuban Missile Crisis, October 1962. (Corbis)

ble above-ground missile launch platforms. These developments helped to make the deterrence relationship between the United States and the Soviet Union more crisis stable by eliminating the incentives of all concerned to use nuclear weapons first in a crisis.

Second, both superpowers shared concerns about the proliferation of nuclear weapons technology to other countries, even their respective allies. China and France joined the nuclear club in the 1960s. China had benefited from the assistance of the Soviet Union in the 1950s but wanted to gain nuclear independence from Moscow. French nuclear capabilities derived from the determination of French President Charles de Gaulle to develop an *independent* nuclear capability outside the NATO alliance, thereby reducing France's reliance on the United States. The West Germans, for their part, also began agitating for some kind of participation in NATO's nuclear deterrent so they would not be totally dependent on decisions made in Washington, London, or Paris.

Concerns about nuclear proliferation led to a surge in diplomatic activity. Superpower interest in slowing the proliferation of nuclear weapons was motivated not only by the desire to impose some control and predictability on strategic competition, but also by a desire to control allies who seemed determined to establish their own independent nuclear capabilities. Indeed, the greatest negotiating challenge of the Nuclear Nonproliferation Treaty related more to how the United States would manage its own allies' nuclear aspirations than to its own nuclear capabilities. When the treaty was signed by the United States in July 1968, both France and China refused to sign (although both qualified as "nuclear weapons states" in the treaty). West Germany did not sign the treaty until after a change of government in 1969, thus clearing the way for U.S. and Soviet ratification.

Third, both superpowers found themselves distracted in the mid-1960s and therefore inclined to keep their mutual competition on a safer plane. Within the Soviet Union, Leonid Brezhnev and Alexei Kosygin replaced Khrushchev in 1964, but it would be at least another four years before Brezhnev had consolidated his political position and power. China was a competitor with the Soviet Union for influence in the Communist world, a competition that made the Third World not only a Cold War "battleground" but also one in which the two Communist giants would compete for influence. Sino-Soviet ideological and political competition and acrimony actually erupted in open hostilities along their border in 1969. For the United States in the mid-1960s, Vietnam was the inexorable policy focus, consuming both attention and resources and diverting military forces from NATO's front line.

By the mid-1960s, the European allies of each superpower started exploring relationships across the East-West divide and contemplating ways in which their destinies might be improved, even though they seemed forever frozen in the immutable blocs of the Cold War. West Germany, in particular, began to probe for improved relations with East Germany, and—when East Berlin proved implacable—to circumvent both East Berlin and Moscow in developing linkages with other Eastern European capitals. For Bonn, it was necessary to overcome the stagnation in European politics that followed erection of the Berlin Wall and to push for progress on German reunification. Similarly, in capitals such as Prague, and, to a lesser degree, Warsaw and Budapest, there was a growing desire for both political and economic liberalization, to which Moscow seemed amenable—at least for a time. Neither set of allies was content with the status quo; both launched policies designed to stimulate political movement.

For the Soviet Union, such political movement was intolerable, and tanks rolled into Prague to suppress the "velvet revolution" in August 1968. The United States—in a year filled with its own political and military crises in Southeast Asia—tolerated the move as a tacit recognition of the Soviets' sphere of influence. Ironically, however, the Soviet move asserted a "rule of the game": The road for the West to Prague or Warsaw went through Moscow. A comparable rule was adopted by the incoming Nixon-Kissinger regime, leading the way to a period of far-reaching arms control treaties and political agreements called "détente."

Détente, 1969–1975

In 1969, the United States and the Soviet Union began the Strategic Arms Limitation Talks (SALT), culminating in the 1972 Interim Agreement on Offensive Arms and the Anti-Ballistic Missile (ABM) Treaty. They followed these negotiations with additional arms control agreements limiting the deployment of both offensive and defensive missiles, strengthening crisis communications (through "Hot Line" Agreements), and beginning negotiations on further strategic arms limitations (*see* Anti-Ballistic Missile [ABM] Treaty; Strategic Arms Limitation Talks [SALT I and SALT II]).

By the early 1970s, a new government in Bonn also had embarked on "Ostpolitik," or an "Eastern policy," that led to a series of agreements with East Berlin, Moscow, Warsaw, and others, as well as a Four Power Agreement on Berlin. Washington was an active participant in this process with Moscow, not so much to record agreements with a Cold War adversary, but to preserve the cohesion of the alliance on which U.S. strength depended.

A new rapprochement in Europe and a stabilization of the bilateral nuclear relationship created further pressures to continue the arms control process within Europe itself, especially since Soviet conventional superiority was viewed as a destabilizing factor in itself. Negotiations within the Conference on Security and Cooperation in Europe (CSCE) began in parallel with negotiations toward a Mutual and Balanced Force Reductions (MBFR) agreement, although neither superpower was especially keen on achieving tangible results. In the end, CSCE produced the Helsinki Final Act in 1975. MBFR persisted without agreement until it was replaced, in 1989, by negotiations toward a Conventional Forces in Europe (CFE) Treaty.

Return to Confrontation, 1976–1985

Despite the appearances of a potential reconciliation of strategic interests that might point the way to the end of the Cold War, détente proved to be a tactical move for both superpowers that masked a deeper political and ideological hostility. Advances in nuclear weapons delivery technology—notably multiple independently targetable reentry vehicles (MIRV) and increasingly accurate guidance systems—created new forms of strategic instability. Instead of being protected in hardened silos, nuclear forces were becoming more valuable as targets (because they housed multiple warheads) and more vulnerable to preemption. The advent of "hard target kill" capabilities increased the incentive of one side to attack first in a crisis, rather than waiting to retaliate. Combined with continuing Warsaw Pact conventional superiority in Europe—which theoretically gave the Soviets a usable war-fighting option as it deterred the United States from escalating to a suicidal nuclear response—the strategic landscape appeared to many analysts in the United States as worse than at any other time in the Cold War.

Part of the solution to these problems was supposed to be a SALT II Treaty that limited Soviet heavy land-based missiles, while parallel efforts within NATO promised deployment of missiles on European soil capable of holding Soviet territory at risk. To many, however, the 1979 SALT II Treaty failed to address the U.S. strategic conundrum, and ratification was doubtful. NATO's "two-track" decision to deploy intermediate-range nuclear forces created its own political friction, since each "track"—deployment and arms control—drew its own share of critics.

At the same time, Soviet behavior in other parts of the world suggested to Washington that Moscow's ultimate political objectives had not changed. Six weeks after U.S. diplomats in Tehran were taken hostage in 1979, the Soviet Union invaded Afghanistan. The United States responded by encouraging, through aid and weapons, a form of "holy war" by Islamic militants and guerrillas against Soviet occupation.

Domestic political change in both countries in the early 1980s further polarized U.S. and Soviet policies, leading to a heightened confrontation reminiscent of the late 1950s. The election of President Ronald Reagan produced a surge in rhetoric about the "evil empire," substantial increases in U.S. defense spending, and a determination to build a national missile defense system that would overturn over a quarter century of theory about what constituted strategic stability. Within the Soviet Union, three leaders—Brezhnev, Yuri Andropov, and Konstantin Chernenko—died in almost as many years. Meanwhile, the occupation of Afghanistan deteriorated into a costly quagmire, Poland's Solidarity movement endured despite martial law, and the Soviet economy continued to decline under the burden of defense spending. The shoot-down of Korean Airlines flight 007 in September 1983 also highlighted the fact that the Soviet military command and control system was becoming increasingly unreliable.

In such circumstances, a new round of arms control negotiations in Geneva to address strategic force reductions, ballistic missile defense, and intermediate nuclear forces was bound to fail. The Soviet walkout from the talks on intermediate nuclear forces in late 1983 spelled stalemate until new Soviet leadership emerged in the person of Mikhail Gorbachev in 1985.

Beginning of the End, 1985–1991

Gorbachev had a radical impact on both the Soviet Union and the dynamics of the Cold War. Domestically, he advocated *perestroika* (restructuring) and *glasnost* (openness) to reform both a declining Soviet economy and a stifling political system. He also announced plans to withdraw Soviet troops from Afghanistan. A protégé of Andropov, who had been head of the Soviet KGB before he succeeded Brezhnev as head of the Communist Party, Gorbachev understood that the Soviet Union could not possibly compete with the United States unless radical reforms were undertaken. Ultimately, Gorbachev could not control the process of perestroika and glasnost, and the entire edifice of the Soviet state unraveled.

Some of Gorbachev's strategic proposals were equally revolutionary, including a 1985 proposal to eliminate nuclear weapons entirely, provided that nuclear disarmament be accompanied by a ban on strategic defenses. The next year, Gorbachev again surprised Reagan at their Reykjavik meeting by proposing elimination of strategic ballistic missiles, again conditioned on elimination of strategic defenses. Reagan would not accept the condition, so there was no agreement—a disappointment to some, but a source of considerable relief within NATO as allies contemplated the future of a U.S. deterrent guarantee without nuclear weapons. The two leaders did agree on total elimination of intermediate nuclear forces and a 50 percent reduction in deployed strategic weapons, culminating in the 1987 Intermediate-Range Nuclear Forces (INF) Treaty and the 1991 Strategic Arms Reduction Treaty (START I), respectively, as well as further improvements to crisis communications through Nuclear Risk Reduction Centers (*see* Intermediate-Range Nuclear Forces [INF] Treaty; Strategic Arms Reduction Treaty [START I]).

For many U.S. observers, Gorbachev's reforms seemed incredible—perhaps too good to be true. Some saw deception. They claimed that Soviet troops were not really leaving Afghanistan, or that unilateral concessions made by Moscow were simply a ploy to get the West to let down its guard. Others saw the call for arms control and nuclear disarmament as a ruse: Doing away with nuclear weapons would increase the importance of the Warsaw Pact's conventional force superiority in Europe. Even skeptics were converted, however, when Soviet negotiators agreed to reduce Warsaw Pact conventional forces to a level 5 percent below existing NATO force levels. Although Gorbachev agreed to such unilateral reductions to reduce defense spending and avert Soviet collapse, his direct intervention trumped the objections of the Soviet military leadership and led to the signing of the CFE Treaty in November 1990.

In 1989, the division of Europe into two hostile camps was nearly over. Gorbachev told East European Communist leaders that they needed to accommodate change on their own. "Roundtable talks" in Poland led to the election of a non-Communist government. The Berlin Wall was brought down. Communist leaders resigned, were expelled, or were executed. In 1990, the Warsaw Pact officially disappeared, and the two Germanys reunified. Remarkably, Gorbachev also acceded to the West's demand that the newly unified Germany remain a NATO member, recognizing that the Soviet Union's World War II foe was less likely to be a threat within NATO, with military restrictions, than as a strategically isolated power in Central Europe.

Within months of signing START I, Gorbachev resigned as Soviet president and the Soviet Union as a political entity ceased to exist. In its place, fifteen "newly independent states" emerged, with the Russian Federation serving as the successor state to the Soviet Union's obligations as well as privileges, including taking its seat in the United Nations Security Council and becoming sole inheritor of the former Soviet Union's nuclear weapons. Belarus, Kazakhstan, and Ukraine yielded control of former Soviet weapons that were deployed on their territory.

After 1990, rhetoric from virtually every political capital spoke of the end of the Cold War, but there were times in which behavior did not match that rhetoric. Strategically, the United States and Russia pursued additional arms control agreements—including START II and the 2002 Moscow Treaty—but Russian concerns about strategic disadvantage vis-à-vis the United States—a distinctly Cold War concern—blocked ratification in the Russian Duma. Arguments for enlarging NATO's membership to include former members of the Warsaw Pact and even Russia sometimes sounded like an extension of a half-century-old strategic competition. By the same token, there has been substantial cooperation in dismantling the legacy of the Soviet Union that would not be possible if Cold War mentalities persisted.

The Cold War in Retrospect

For decades, the Cold War provided a clear and often one-dimensional lens through which policymakers were able to gauge foreign policy actions. As U.S. officials defined their global role following World War II, the choice of whether to intervene in a particular crisis often resolved to a single question—What side are the Communists on? In the chaotic and globalized world of the twenty-first century, with amorphous and unprecedented strategic threats facing the United States, the relative simplicity of the Cold War sometimes looks appealing.

For U.S. policy, the Cold War also reflected a remarkable bipartisan consensus in American foreign policy priorities. America had become a global power for reasons largely shared across the domestic political spectrum and among America's allies, notwithstanding often-difficult debates about tactics, methods, and policy priorities. That consensus, too, has dissipated as new debates have emerged about the ends and means by which America's power in the world is to be exercised.

American policy in the Cold War—beginning with containment—was essentially a status quo policy. The United States sought to protect the status quo from a revolutionary ideology antithetical to U.S. interests. The policy required more than "patience" and "vigilance," as George Kennan had suggested when he introduced the policy of containment in his famous 1946 "long telegram." It demanded that the United States manage a strategic relationship in which it was increasingly vulnerable by virtue of the dynamics of the nuclear age. Likewise, it also demanded that the United States manage a set of alliance relationships, lest the West appear divided and invite aggression. Ironically, in both these endeavors, the United States found a remarkable degree of shared interests with its Cold War adversary, notwithstanding the ideological incompatibility of the two countries. Perhaps more than anything else, that is what helped keep the Cold War "cold."

—Schuyler Foerster

See also: Arms Control; Containment; Cuban Missile Crisis; Deterrence; Game Theory; North Atlantic Treaty Organization; Russian Nuclear Forces and Doctrine; United States Nuclear Forces and Doctrine

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COLLATERAL DAMAGE

Collateral damage is unintentional or incidental damage affecting facilities, equipment, or personnel that occurs as a result of deliberate military action against targeted enemy forces or facilities. According to the U.S. Defense Intelligence Agency's Battle Damage Assessment (BDA) Quick Guide, collateral damage is assessed and reported during the BDA process.

Determining how much care must be taken to minimize collateral damage constraints is a commander's responsibility. If national command or theater authorities do not predetermine constraint levels for collateral damage, a corps or higher commander will normally be responsible for doing so. When a commander is planning strikes near his or her own forces, there is always some element of risk. Usually, conservative calculations will be used (except under emergency conditions) to minimize risks to friendly forces. Planning also may lead to maximizing collateral damage to enemy facilities near planned targets.

Conventional weapons have relatively small effective radii against personnel, but their use in close support of tactical operations still involves some risk to friendly forces. Nuclear weapons increase this risk considerably because of their larger effective radii. Therefore, in the analysis of a potential nuclear target close to friendly troops or to a friendly civilian population, safety risk is carefully evaluated by planners and commanders. When weapons are considered for employment against targets close to friendly forces or civilians, troop safety considerations may determine whether nuclear weapons will be used. If they are used, troop safety may influence the selection of yield, delivery means, location of the desired ground zero, height of burst, and time of burst, as well as the ground commander's scheme of maneuver. Because of delivery errors and prevailing weather and terrain conditions, calculating the risk to friendly troops involves the use of probabilities and good judgment. It would be desirable to have a 100 percent assurance that no friendly casualties would result from the use of nuclear weapons, but as long as the possibility of delivery error exists, such an assurance is unlikely. As a rule, the commander will want a very high assurance (0.99 probability) that his troops will not be exposed to weapon effects higher than those considered acceptable given the military situation on the ground.

The high risk of great collateral damage is partly behind the call in the 2001 Nuclear Posture Review to develop low-yield nuclear weapons and earth-penetrating delivery systems. Critics charge, however, that by reducing the potential for collateral damage, these weapons lower the nuclear threshold, making it more likely that U.S. officials will decide to use nuclear weapons in dire military circumstances.

—Mike Kaufhold and James J. Wirtz

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COMMAND AND CONTROL

Command and control generally refers to a set of protocols and communication links and procedures that ensure that weapons of mass destruction, especially nuclear weapons, are launched only upon the orders of authorized individuals. This includes positive control—ensuring that weapons are released in a timely manner upon the order of civil authorities—and negative control—preventing accidental, irrational, and unauthorized release. There is a trade-off between these two objectives. Safeguards that can always guarantee negative control might be too difficult to release if the time ever came to launch weapons, especially if the launch crews were given short notice.

Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, coordinating, and controlling forces and operations in the accomplishment of the mission.

Perhaps the most essential component of precluding accidental or unauthorized launch of a delivery vehicle carrying a nuclear weapon is to ensure that procedures are in place before a crisis occurs, obviating the need to make critical decisions during times of highest stress. Breakdowns in command and control have occurred in the past and will likely occur again. In the 1950s, a flock of Canadian geese was interpreted as a Soviet bomber attack by the U.S. early warning radar system. A similar event occurred in 1960 when meteor showers and lunar reflections spooked early warning systems. In 1980, the failure of a 46-cent computer chip led to mistaken indications that a Soviet submarine had just launched its missiles against the United States. In each case, there were sufficient backup systems and safeguards in place to prevent a panicked retaliatory attack.

Ultimate nuclear command authority in the United States is exercised by the president, vice president, and secretary of defense, collectively referred to during the Cold War as the National Command Authority (NCA). Although this process is still in place today, the NCA designation has been eliminated.

By the 1960s, the United States set up a decentralized system consisting of primary and secondary (including airborne) command centers to provide redundancy in case of a Soviet strike, ensuring the ability to launch retaliatory strikes against Moscow. This was deemed crucial as a means of preventing Soviet strikes in the first place as part of the larger doctrine of mutual assured destruction. Although authorization to release nuclear weapons theoretically can come only from the president, most sources believe that the authority to fire the U.S. strategic arsenal might devolve to senior military officers in the event of a catastrophic attack that disabled presidential communication or decision-making ability. Details about the command and control procedures maintained by nuclear states are highly guarded secrets.

—James Joyner

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COMMITTEE ON THE PRESENT DANGER

In the early 1950s and again in the mid-1970s, former top policymakers, leading academics, and industrial leaders formed citizens' groups called the Committee on the Present Danger to warn of rising Soviet capabilities and to support tough U.S. policy responses. The two groups were distinct, although there was a small overlap of membership and the second group consciously chose to revive the name.

The first committee was formed in 1950 soon after the completion of National Security Council Document 68 (NSC-68) and the start of the Korean War. Its founders were Harvard University President James Conant, former Undersecretary of the Army Tracy Voorhees, and atomic scientist Vannevar Bush. Soon other leading university presidents, including Dwight D. Eisenhower (then at Columbia University), and other former government officials became involved. The group repeatedly warned of the aggressive designs of the Soviet Union and argued for a response in the form of European rearmament, a U.S. military buildup, and universal military service. The goal of its members was to rally public opinion behind the internationalist and more militarist containment policies of the Harry Truman administration and NSC-68, in particular (*see* Cold War).

The second committee was formed in 1976 in response to what some saw as a revived Soviet threat, the softness of détente and arms control, and the emergence of the Trilateral Commission as a voice of the elite establishment. Its founders included former Undersecretary of State Eugene Rostow, former author of NSC-68 and Secretary of the Navy Paul Nitze, former Secretary of the Treasury Henry Fowler, and roughly 150 other government, academic, and business elites. Like the first committee, the group warned of rising Soviet military capabilities and goals and argued that the only appropriate response was U.S. military strength. The group became a leading opponent of the treaty resulting from the Strategic Arms Limitation Talks (SALT II) and took some credit for its failure.

Technically, the committee was a nonprofit research organization, not a lobbying group, but the members used their extensive governmental contacts to try to shape government decisions. The committee also produced research reports, worked closely with newspaper editorial boards, and conducted polls attempting to show that although public sentiment in general favored arms control, few citizens understood or supported the terms of SALT II. With the 1980 election, committee members moved back into positions of power. Ronald Reagan himself had been a member of the committee, and thirty-two other members joined his administration, becoming leading designers of his policies.

—John W. Dietrich

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COMPELLENCE

Compellence is an attempt to get an adversary to perform a requested action by threatening the use of force if the adversary does not comply with the request. It includes convincing the target to do something, to reverse an action already taken, or to otherwise change the status quo. An attempt to convince a state to give up or roll back its nuclear weapons program is compellence, for example, when marked by threat of force.

The term "compellence" was created by Thomas Schelling to illustrate the difference between two different types of coercion: "deterrence," by which the coercer tries to convince the adversary not to carry out a specific action that he intends to perform, and "compellence," by which the coercer is attempting to get the adversary to carry out a specific action. Both tasks require the threat of force (or some adverse action) to make noncompliance with the demands more costly for the adversary than compliance.

Compellence is generally regarded as a difficult task, given that it is harder to get people to do something than to get them to refrain from doing something. When a state is compelled, it appears weak. If the adversary performs the requested task in response to a threat, its submission to following threats will often be obvious to onlookers. Thus, there can be reputational costs associated with bowing to the coercer's will. Complying with the compeller's demands may cause the target to "lose face" at home or abroad and may cause domestic instability or even encourage the coercer or other states to make further demands. By contrast, if a state is deterred, it is difficult to tell whether it did not perform the action because it was coerced or because the action was not in its interests for another reason. Proving that deterrence actually succeeded (that is, demonstrating conclusively why something did not happen) is very difficult.

There are two ways to increase the likelihood that compellence will succeed. First, the party attempting to compel an adversary can increase the cost of the threat. Second, the party practicing compellence can increase the credibility of its intention to carry out the threat. Threats usually must be both significant and credible to succeed. If the adversary expects to suffer greater costs from complying with the demand than he expects if the threat is carried out, then compellence is likely to fail. If the adversary is certain that the coercer will follow through with a strong threat, compellence is likely to succeed.

The United States often tries to compel nuclear proliferators to give up their nuclear programs. Cases of successful compellence include Ukraine, Belarus, Kazakhstan, and South Korea, while compellence has failed in North Korea, India, and Pakistan.

—Andrea Gabbitas

See also: Deterrence

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COMPREHENSIVE TEST BAN TREATY (CTBT)

The Comprehensive Test Ban Treaty (CTBT) is an international agreement to ban nuclear testing in any environment. The treaty is an extension of efforts begun in the mid-twentieth century to limit nuclear weapons proliferation. It is not yet in force. The CTBT requires that all member states enact a moratorium on detonating nuclear weapons, in effect preventing new states from acquiring them and current nuclear powers from developing newer and more advanced nuclear weapons (*see* Moratorium). Originally proposed in the 1950s, but not opened for signature until 1996, the treaty will enter into force following ratification by the 44 states that own nuclear power or research reactors. As of September 2004, 32 of the 44 nuclear-capable states had ratified the treaty, 116 total states had ratified, and 172 states had signed. Under President Bill Clinton, the United States signed the treaty in 1996, but the Senate failed to ratify it in a vote taken in October 1999.

With international concerns over Cold War tensions and radiological fallout rising, Prime Minister Jawaharlal Nehru of India first suggested a treaty to ban nuclear explosions in 1954. U.S. presidents Dwight D. Eisenhower and John F. Kennedy backed the idea of such an agreement, and the international community eventually came to support a Limited Test Ban Treaty (*see* Limited Test Ban Treaty [LTBT]). Such a treaty was signed in 1963, outlawing nuclear tests underwater, in space, and in the atmosphere. The 1968 Nuclear Nonproliferation Treaty prohibited non–nuclear weapons states from acquiring such weapons and committed the declared nuclear powers (the United States, the Soviet Union, the United Kingdom, France, and China) to eventual, although nonbinding, nuclear disarmament (*see* Nuclear Nonproliferation Treaty [NPT]). A comprehensive ban, however, would prove to be illusive. Given the state of verification technologies during this period, many critics doubted that underground explosions could be accurately detected or differentiated from normal seismic activity, and little progress was made on CTBT negotiations.

The end of the Cold War and improvements in monitoring technologies led to a renewed interest in a zero-yield ban on nuclear testing, with the United Nations Conference on Disarmament beginning a three-year negotiation on the CTBT in 1993 (*see* Conference on Disarmament). In addition to a prohibition on nuclear weapons explosions, the treaty establishes organizations to implement verification measures, resolve international disputes, and periodically review the status of or amend the treaty. President George H. W. Bush did not explicitly endorse the treaty, but he did initiate a moratorium on U.S. testing in 1992 that is still in effect. The Clinton administration signed the treaty but waited three years to submit it to the Senate for ratification because of foreign policy disagreements with some Republican senators. Even then, political hostility and lingering doubts on the effectiveness of verification regimes led the Senate to reject the treaty 48–51, mostly along party lines and well short of the two-thirds majority needed for ratification. President George W. Bush did not pursue another vote on ratification.

The CTBT consists of 17 articles and various annexes and protocols detailing the scope of the agreement and will enter into force 180 days after the last of the 44 nuclear-capable states ratifies it. The formal organization of the regime includes a Conference of States Parties, an executive council consisting of 51 members that serves as the executive organ of the Comprehensive Test Ban Treaty Organization (CTBTO), and a Technical Secretariat that assists member states with implementation measures.

Following implementation of the treaty, states parties will be able to activate various noncompliance measures, and a verification regime will begin monitoring compliance with the test ban. Verification measures in the CTBT include an International Monitoring System (IMS) of more than 300 seismic, radiological, hydroacoustic, and infrasound detectors around the world set up to detect seismic and other activities that could indicate a nuclear detonation; they will transmit data to the CTBTO headquarters in Vienna. The headquarters will analyze suspected events and distribute the information to member states. The treaty text details the locations of IMS facilities, which were designed to ensure global coverage. In addition to detecting possible nuclear explosions, the monitoring stations can supply member states with information on volcanic, seismic, and nonnuclear radiological activities. IMS facilities are owned by the state in which they are located. In some cases, these facilities are preexisting installations; in others, the CTBTO and relevant states parties must yet fund and initiate their construction. In the event that member states suspect an illegal nuclear explosion, the CTBT allows for a series of options for on-site inspections, including overflight observation and photography, environmental sampling, and drilling to obtain radioactive samples. The CTBT does not explicitly provide for noncompliance measures other than the suspension or restriction of rights outlined in the framework of the treaty. However, the treaty does recommend that states found to be in violation of its obligations be subject to actions by the United Nations, including sanctions (*see* Underground Testing; Verification).

During negotiations, the United States ensured that the treaty banned only nuclear explosions, and not all activities resulting in nuclear energy release. Given this wording, the CTBT would allow the United States (and other signatories) to conduct a range of nuclear weapons tests, such as subcritical explosions involving fissile material, which could result in a release of nuclear energy, to guarantee the reliability of its nuclear weapons stockpile.

Without ratification from the United States and several other countries, the treaty cannot enter into force (*see* Entry into Force). Among the other declared nuclear powers, Russia, France, and the United Kingdom have ratified the treaty, and China has signed it. India, Pakistan, North Korea, and Iraq would also need to ratify the CTBT in order for it to enter into force because they all possess or are suspected of developing nuclear weapons. However, none of these states has yet signed the treaty.

—*John Spykerman*

See also: Arms Control; Limited Test Ban Treaty; Nuclear Test Ban; Peaceful Nuclear Explosions Treaty (PNET); Ratification

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CONFERENCE ON DISARMAMENT

The Conference on Disarmament (CD) is an autonomous negotiating body that serves as the principal forum established by the international community to negotiate multilateral arms control and disarmament agreements. Although it is not considered a United Nations (UN) body, the UN does provide administrative support and negotiating subjects. Informal CD-UN linkages occur because most nations are represented by the same diplomats in the CD, the UN Disarmament Committee (UNDC), and the First Committee (disarmament and international security) of the UN during formal sessions. The CD submits a purely informational annual report to the UN.

The CD had its genesis in the late 1950s when the UN General Assembly (UNGA) began to pay more attention to disarmament matters, primarily because of the increasing concern over growing nuclear arsenals. Consequently, the UN First Committee was established in 1957 but quickly collapsed when the Soviet Union refused to participate. Various attempts to resurrect multilateral disarmament talks floundered because of Cold War animosities until 1962, when both the Soviet Union and the United States agreed to establish the Eighteen Nation Disarmament Committee (ENDC). Membership was based on five members from each alliance (the North Atlantic Treaty Organization [NATO] and the Warsaw Pact) and eight countries from different geographical areas. Membership expanded to thirty in 1969 when the group became the Conference of the Committee on Disarmament (CCD). The name was changed again in 1978 to the Conference on Disarmament, and membership increased to forty. The CD predecessor bodies successfully negotiated a number of important arms control agreements, notably the Nuclear Nonproliferation Treaty, the Biological and Toxin Weapons Convention, the Seabed Arms Control Treaty, and the Environmental Modification Convention. The CD has negotiated two treaties: the Chemical Weapons Convention (signed in 1993 and entered into force in 1997) and the Comprehensive Test Ban Treaty (signed in 1996, not yet in force).

Currently the CD has sixty-six members (including all five nuclear weapon states) and more than forty other states have observer status. These members are ostensibly divided into three political groups: the Western Group, consisting primarily of NATO state members of the CD, Australia, and Japan; the Eastern Group, consisting of many of the former Warsaw Pact states; and the Neutral/Nonaligned Group. The People's Republic of China has refused to join any group (referring to itself as the Group of One), and since the end of the Cold War the dynamics of these groups have changed significantly, with a number of states breaking out of these traditional groupings to form other politically "like-minded" blocs. The composition of these blocs depends on the particular issue to be addressed.

The CD meets at the UN's Palais des Nations in Geneva for three sessions each year, each lasting approximately two months. (Until 2000 it met for two three-month sessions each year.) It conducts its business through plenary sessions in which representatives make basic policy statements, through informal meetings, and through ad-hoc committees established to address specific issues. Plenary sessions are open to the public and have verbatim records. The ad-hoc committees submit reports to the conference, which are incorporated into the CD's annual report to the UNGA. Although many delegations submit and circulate proposals and working papers, there are formal records only of the plenary sessions. Member states agreed that the work of the CD would be undertaken by consensus and under its own rules of procedure. Members also adopt their own agendas based on input from the UNGA and proposals made by CD members. The UN secretary general appoints the secretary of the CD, who acts as his personal representative, and assists the CD in organizing the business and timetables for scheduling sessions. The presidency of the CD rotates on a monthly basis in alphabetical order. Consensus by the member states is a prerequisite for any measure to clear the CD.

The CD's current multilateral arms control initiatives include the cessation of the nuclear arms race and nuclear disarmament; prevention of nuclear war; prevention of an arms race in outer space; the establishment of effective international arrangements to assure non–nuclear weapon states against the use or threat of use of nuclear weapons (*see* Negative Security Assurances [NSAs]); the identification and limitation of new types of weapons of mass destruction (such as radiological weapons); and the creation of a comprehensive program of disarmament and transparency in armaments. Discussions of a Fissile Material Cut-off Treaty also have been undertaken, but as with all the other issues up for discussion, there has been little or no progress on the matter. Nevertheless, the CD is the only multilateral forum for disarmament and arms control negotiations, and many states believe that the continued dialogue that it facilitates is important as a transparency- and confidence-building measure that enables states to continue to strive toward disarmament in all its forms.

—*Guy Roberts*

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CONFERENCE ON SECURITY AND COOPERATION IN EUROPE (CSCE)

The Conference on Security and Cooperation in Europe (CSCE) was the precursor to what is now the Organization of Security and Cooperation in Europe (OSCE), with headquarters in Vienna, Austria. It currently includes fifty-five participating states, including all European countries, all of the former Soviet Union, and the United States and Canada.

Originally opened in July 1973 among the members of the North Atlantic Treaty Organization (NATO), the Warsaw Treaty Organization (WTO), and several neutral states, the CSCE produced the Helsinki Final Act on August 1, 1975. That document included provisions relating to security ("Basket I"), economic cooperation ("Basket II"), and humanitarian and other fields ("Basket III").

The Helsinki Final Act also provided for a series of follow-up meetings during which states would discuss progress in each of these areas. These were held in Belgrade (1978), Madrid (1983), and Vienna (1989). Each of these meetings represented standalone negotiations; no CSCE institutions continued to work on this extensive agenda in the interim between the formal meetings. The 1990 Charter of Paris for a New Europe occurred alongside signature of the Conventional Forces in Europe (CFE)

Treaty and the Vienna Document on Confidence and Security Building Measures (CSBMs), marking the end of the Cold War in Europe (*see* Confidence- and Security-Building Measures [CSBMs]). At the 1992 Helsinki Follow-Up Meeting, the CSCE began to formalize its structures, seeking to adapt to the needs of the post–Cold War world. In 1994, the CSCE changed its name to the Organization of Security and Cooperation in Europe.

The CSCE had begun as a creature of the Cold War. Since the 1950s, the Soviet Union had repeatedly called for a "European Security Conference" so that Europeans—excluding the United States and Canada—might discuss their security landscape. In the early 1970s, the Soviets agreed to the CSCE—including the United States and Canada as well as thirteen neutral European states—as a parallel to launching the Mutual and Balanced Force Reduction (MBFR) negotiations to limit NATO and Warsaw Pact conventional forces.

Within the security "basket," the CSCE gave birth to confidence- and security-building measures designed "to contribute to reducing the dangers of armed conflict and of misunderstanding or miscalculation of military activities which could give rise to apprehension, particularly in a situation where the participating States lack clear and timely information" (Helsinki Final Act, Sec. 2, para. 4). Observers also credit the human rights focus of Basket III for giving a certain political cover to "Helsinki human rights" dissidents within the Soviet Union and Eastern Europe.

The end of the Cold War brought new challenges. Newly independent states faced the need to restructure their political and economic systems. Ethnic conflict stimulated internecine violence. Over the past decade, the OSCE has expanded its reach beyond CSBMs to encompass peacekeeping and political observer missions as a means of conflict prevention and management. Additional OSCE offices focus on democratic institutions, freedom of the media, and national minorities. Economic forums address the challenges of privatization and conversion to new civilian industries. More recently, the OSCE has added control of light weapons, terrorism, and trafficking in human beings to its agenda.

—*Schuyler Foerster*

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CONFIDENCE- AND SECURITY-BUILDING MEASURES (CSBMS)

The concept for confidence- and security-building measures (CSBMs) emerged in the early 1970s as a complement to arms control and disarmament. Within the 1975 Helsinki Final Act of the Conference on Security and Cooperation in Europe (CSCE), "Basket I" focused on security issues, whereby participating states agreed to undertake measures designed to reduce the dangers of armed conflict and of misunderstanding or miscalculation of military activities that could give rise to apprehension, particularly in situations where participating states lacked clear and timely information (*see* Conference on Security and Cooperation in Europe [CSCE]).

The CSCE represented a multilateral process involving neutral states as well as members of the North Atlantic Treaty Organization (NATO) and the Warsaw Pact. Participants believed that development of CSBMs were complementary to other ongoing nuclear and conventional arms control negotiations that were essentially bilateral between the two blocs or their superpowers.

Initial CSBMs in the Helsinki Final Act included a requirement to issue prior notification of military maneuvers and movements and exchange of observers. In 1986, CSCE participating states agreed in the Stockholm Document to lower notification thresholds and provide for mandatory on-site inspections to verify notified military maneuvers. Subsequent Vienna Documents (1990, 1992, 1994, and 1999) added detailed requirements to agreements calling for the exchange of military information, further lowered thresholds for notifying military maneuvers, and introduced new measures relating to reporting of hazardous incidents and improved crisis communications.

The initial emergence of CSBMs in Europe reflected fears about instability in the military standoff between NATO and the Warsaw Pact. For many, the concentration of substantial opposing military forces in a high state of readiness in such close proximity recalled the specter of 1914, in which miscalculation and fear prompted actions that were seen as threatening by others, causing a crisis to escalate into war. Likewise, the lack of transparency between NATO and Warsaw Pact military formations and operations was viewed as a source of miscalculation. CSBMs were viewed largely as a mechanism to begin creating transparency, reducing the likelihood of inadvertent escalation or accidental war.

There is a strong political component to CSBMs. Although the initial provisions in the Helsinki Final Act were quite general, supporters believed that it was important to establish the precedent of reporting to the opposing alliance the details about large military maneuvers. Subsequent agreements offered specific guidelines about the conduct of required notifications, set more detailed parameters for exchange of military information, and established the important precedent of on-site inspection to verify exchanged information. These precedents also spilled over into the worlds of nuclear and conventional arms control, where information exchange and on-site inspection are crucial to maintaining confidence in the regimes.

Since the end of the Cold War, the relevance of the Vienna Documents for NATO members and states from the former Warsaw Pact has declined significantly. Yet the principles and experience represented by this effort have potential application in other contexts. Nuclear CSBMs between the United States and Russia—including crisis communications, information exchange, on-site inspection, and exchange of officers in respective command centers—are being discussed. India and Pakistan also might benefit from CSBMs to reduce the risk of escalation in their enduring rivalry. In the Balkans, a regime of CSBMs is considered essential to ensuring some transparency in military relationships and improving crisis stability.

—Schuyler Foerster

See also: Crisis Stability; Implementation; Verification

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CONTAINMENT

"Containment" is virtually synonymous with the Cold War—it is the grand strategy that the United States pursued for some forty-five years vis-à-vis the Soviet Union. Essentially a defensive strategy, it was a policy designed to manage an antagonistic relationship in which it was not possible to quickly defeat the adversary. The strategy required the United States to confront Soviet power and influence wherever and whenever necessary, even at the risk of war. Containment reflected the traditions of classic balance-of-power thinking (*see* Cold War).

The term was first coined by George F. Kennan, writing under the pseudonym "X," in an article entitled "The Sources of Soviet Conduct" published in the July 1947 edition of *Foreign Affairs.* Kennan—then director of the U.S. State Department's new Policy Planning Staff—called for a "long term, patient but firm and vigilant containment of Russian expansionist tendencies" (X, p. 575). Kennan's anonymity did not survive for long, as the article drew substantial publicity, and the concept of containment became elevated to doctrine.

As Kennan noted in his memoirs, he had not intended the article to be a formal policy pronouncement. The article prompted Walter Lippman to pose his own critique of containment in the pages of the *New York Times* and published in the same year in his *The Cold War: A Study in U.S. Foreign Policy.* Kennan also recounted how his arguments had been misunderstood and acknowledged his agreement with much of Lippman's critique, noting "My only consolation is that I succeeded in provoking from him so excellent and penetrating a treatise" (Kennan, p. 360).

However unofficial its intentions, Kennan's thesis sparked a public debate about America's role in the immediate postwar world and found resonance in policy responses from the Truman administration through the end of the Cold War and beyond.

Kennan's Thesis

Containment represented a critique of the prevailing notion in Washington that the United States could somehow work with the Soviet Union—its wartime ally—in restoring peace in Europe. President Franklin D. Roosevelt had hoped to integrate the Soviet Union into the postwar international system through the United Nations, thereby giving it both status and the security it so desperately needed.

Washington's ambassador to Moscow, W. Averill Harriman, similarly advocated the use of economic enticements to an impoverished nation to induce the Soviet government to be a responsible player in world affairs.

In Moscow in February 1946, Kennan responded to a request from Washington for an analysis of increasingly uncooperative and even hostile Soviet behavior. The result was the famous "Long Telegram." Its central thesis was, "We have here a political force committed fanatically to the belief that with [the] U.S. there can be no permanent *modus vivendi*" (quoted in Kennan, p. 557). The Soviet government *presumed* a hostile international system, a conviction deriving from a combination of Soviet ideology's belief in the antipathy of capitalist states, a traditional Russian fear of foreign influences, and the expediency of using foreign enemies to justify totalitarian rule. Any policy based on the expectation that it would influence the Soviet government to cooperate with Western aims was therefore depicted as being bound to fail. U.S. "dealings with Russia must be placed on [a] realistic and matter of fact basis" (quoted in Kennan, p. 559).

Kennan's "X" article brought this same argument about the nature of Soviet society into the public view. More important than the policy prescriptions, Kennan was concerned with explaining "the sources of Soviet conduct." It also coincided with growing concerns that Moscow actually favored a dismembered Germany riddled with debt and reparations, dragging down Europe's recovery and fostering the conditions for greater Communist influence—a scenario that would simply repeat with greater ferocity the mistakes following World War I and place an enormous burden on the United States both militarily and financially. Already, the Truman Doctrine and the Marshall Plan had committed the United States to the support of freedom and the economic recovery of Europe. Western governments concluded that they should consolidate and strengthen what they had so as to stem further political and economic deterioration and to block Communist expansion.

The more controversial elements of Kennan's thesis stemmed from the article's sweeping policy prescriptions: "Soviet pressure against the free institutions of the Western world is something that can be contained by the adroit and vigilant application of counterforce at a series of constantly shifting geographical and political points, corresponding to the shifts and maneuvers of Soviet policy, but which cannot be charmed or talked out of existence." Out of context, this prescription suggested a U.S. policy that was essentially reactive, responding to Soviet challenges wherever they occurred. To many, containment suggested that the United States should rely on force to stem the spread of Soviet military and diplomatic influence.

The Critique of Containment

Kennan argued that containment was a long-term strategy but that the fragile crust of Soviet power would eventually give way to its own internal political, economic, and social weaknesses: "The United States has it in its power to increase enormously the strains under which Soviet policy must operate, to force upon the Kremlin a far greater degree of moderation and circumspection than it has had to observe in recent years, and in this way to promote tendencies which must eventually find their outlet in either the break-up or the gradual mellowing of Soviet power" (X, p. 582).

Nonetheless, critics such as Lippman argued that the United States would be condemned to maintaining an indefinite defensive posture against Soviet expansionism for several reasons. The projections of inevitable Soviet self-destruction were optimistic and risky; the strategy required a mobilization of American resources incompatible with the nature of American politics; the United States would have to create and maintain subordinate alliances with nations along the Soviet periphery and become excessively involved in those nations' internal affairs; and the prospect of eventual war between the United States and the Soviet Union on a European battlefield would ultimately undermine the "natural" alliance between the United States and Western Europe.

Ironically, virtually all of these criticisms reflected Kennan's later critique of how containment was applied over the ensuing years. Kennan consistently argued that his concept of containment was neither universal nor militaristic. Throughout the subsequent four decades, however, successive U.S. administrations struggled with both issues—how universal the doctrine of containment should be, and how much should be invested in the military dimension of policy, especially as nuclear weapons played an increasingly dominant role in the standoff between the superpowers.

Issues in Implementing Containment

Kennan himself argued in 1948 at the National War College, "We are great and strong; but we are not great enough or strong enough to conquer or to change or to hold in subjugation by ourselves all . . . hostile or irresponsible forces. . . . To attempt to do so would mean to call upon our own people for sacrifices which would in themselves completely alter our way of life and our political institutions, and we would lose the real objectives of our policy in trying to defend them" (quoted in Gaddis, p. 28).

Such logic reflected an essentially "particularist" view of American strategy, which one would expect from a traditional "realist" who differentiated between vital and less-than-vital national interests. Kennan, for example, dissented from the Truman Doctrine's aid to Greece and Turkey on two counts. First, he objected to Truman's sweeping statement in support of "free peoples who are resisting subjugation by armed minorities or outside pressures," arguing that it would not necessarily be in U.S. interests to come to others' aid in every instance and that the United States could not fulfill such an expectation (Kennan, pp. 319–324). Second, he was skeptical of the need to give much aid to Turkey, since he doubted communism would ever be able to make substantial gains in the Islamic world.

Over time, U.S. administrations often took a more universalist view of containment, leading them into conflicts in which they had few interests other than to oppose a political force influenced by communism. In 1950, Paul Nitze—occupying Kennan's former position as director of the State Department's Policy Planning Staff—argued in National Security Council Document 68 (NSC-68): "It is not an adequate objective merely to check the Kremlin design, for the absence of order among nations is becoming less and less tolerable. This fact imposes on us, in our own interests, the responsibility of world leadership" (*NSC-68,* Sec. IV[B]). Under President Dwight D. Eisenhower, Secretary of State John Foster Dulles likewise presided over the establishment of a system of alliances around the periphery of the Soviet Union reminiscent of Lippman's earlier critique. And President John F. Kennedy promised "to pay any price, bear any burden" as the 1960s ushered in a series of "proxy" conflicts in virtually every Third World region, and, most tragically, in Vietnam.

By the end of the 1940s, Kennan's call for subtlety in the application of containment seemed increasingly out of place. Nitze began drafting NSC-68 in response to communism's victory in China and Soviet detonation of an atomic bomb. Even here, the debate is instructive. Kennan, for example, argued that these developments were not really cause for alarm: First, any alliance between the Soviet Union and the new Communist China would ultimately break down because of Russo-Chinese antipathy; second, Soviet membership in the nuclear club was inevitable, even if it came earlier than expected, and the United States had no intentions of using its nuclear monopoly to eliminate the Soviet Union anyway. By this time, however, Kennan's views were no longer mainstream.

The "misunderstanding" that Kennan lamented most was that he had not meant "the containment by military means of a military threat, but the political containment of a political threat" (Kennan, p. 358). Kennan, for example, also dissented from early plans to incorporate all of Western Europe—including West Germany—into the North Atlantic Treaty Organization (NATO). In a memo to Secretary of State George Catlett Marshall in 1948, Kennan argued that "this would amount to the final militarization of the present line through Europe . . . [creating] a situation in which no alteration or obliteration of that line could take place without an accentuated military significance" (quoted in Gaddis, pp. 72–73).

For Nitze, like others after him, the West needed "superior aggregate military strength . . . without which containment is no more than a policy of bluff" (*NSC-68,* Sec. VI). As the United States implemented containment through the years, military force—particularly NATO in Europe—played a major role in U.S. efforts to contain the Soviets. Nitze argued in NSC-68 for a major increase both in nuclear capability and in conventional military forces. Later, Dulles, like Lippman, argued that the United States could not sustain such large outlays for defense, but relied on new nuclear weapons technologies to fill the gap. Kennedy and his successors tried to reduce reliance on nuclear weapons but found that increased conventional military power was expensive, provoked concerns from allies about the credibility of the nuclear guarantee, and was still inadequate in dealing with conflicts such as Vietnam. President Richard M. Nixon tried to manage the military threat through arms control. President Ronald Reagan reverted to a military buildup even as he tried to advance substantial arms reductions.

Contemporary Strategy: Is Containment Relevant?

In the end, Kennan's prediction came true—the Soviet Union disintegrated through its own weaknesses. As Kennan suggested, it ultimately could not compete in the realm of ideas and economics, critical failings that slowly eroded the basis of Soviet military power. Yet, containment continued as a dominant force in U.S. policy thinking, applied to North Korea, Iran, Iraq, and, for many, to China. For those who authored President George W. Bush's 2002 National Security Strategy, the issue has been whether containment is too passive: "We seek instead to create a balance of power that favors human freedom: conditions in which all nations and all societies can choose for themselves the rewards and challenges of political and economic liberty" (*National Security Strategy*). In June 2003, applauding Operation Iraqi Freedom, Thomas Donnelly of the American Enterprise Institute declared, "In [the Bush Doctrine's] rejection of containment and deterrence, it has likewise restored to prominence the historic characteristics of American policy: a proactive defense and the aggressive expansion of freedom."

Containment worked in the Cold War. It required patience—ultimately the Soviet Union fell—but the threat was clear and understandable, and there were few alternatives. Today, threats are more amorphous, and arguably more lethal, than in the Cold War. The ends of policy are more universal than particular, and military force is a more usable instrument of national policy. The dilemmas of containment remain—but how long can these policies be sustained and what are the risks between trying to change strategic realities on the ground versus trying to contain their effects?

—Schuyler Foerster

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CONTROL RODS

See Reactor Operations

COOPERATIVE THREAT REDUCTION (THE NUNN-LUGAR PROGRAM)

Since 1991, the United States has sponsored the Nunn-Lugar Cooperative Threat Reduction Program to assist the states of the former Soviet Union dismantle their weapons of mass destruction, secure their nuclear weapons and associated materials, technology, and expertise, and convert their nuclear facilities to other purposes. U.S. Senators Sam Nunn (D–GA) and Richard Lugar (R–IN) cosponsored the 1991 legislation that created this program. The term "Nunn-Lugar" thus has come to refer to the full range of threat reduction and nonproliferation programs undertaken by the U.S. government in cooperation with the states of the former Soviet Union, including those managed by the U.S. Departments of Commerce, Energy, and State. "Cooperative Threat Reduction (CTR)" is more accurately applied to the U.S. Department of Defense element of Nunn-Lugar.

At the time of its collapse, the Soviet Union possessed approximately 30,000 strategic and tactical nuclear weapons in its arsenal, in addition to some 1,000 tons of highly enriched uranium, 200 tons of plutonium, 40,000 tons of chemical weapons agents, and a massive biological weapons program. Perhaps more significantly, the Soviet collapse created three new nuclear weapons states in Belarus, Kazakhstan, and Ukraine. In the immediate aftermath of the Cold War, the denuclearization of these three new nuclear powers was not a foregone conclusion. Most analysts believe that the eventual denuclearization of all three states by the mid-1990s—leaving Russia as the sole former Soviet nuclear

Russian soldiers wearing protective suits check chemical agents at a military base for troops specializing in chemical warfare, east of Moscow, in 1993, as part of an initiative under the Cooperative Threat Reduction program. (Reuters/Corbis)

legacy state—would not have occurred, or would have taken a much longer time, without the assistance of the Nunn-Lugar Program.

Although Nunn-Lugar is a unique program that was fraught with growing pains, bureaucratic battles, and international misunderstandings, the program has matured into a complex and comprehensive foreign policy and national security mechanism. Nunn-Lugar has generated considerable domestic momentum throughout the legislative, executive, industrial, and nongovernmental communities, which has carried it through the ebbs and flows of U.S.-Russian bilateral relations.

Organizational Elements of CTR

The various U.S. government agencies that manage elements of the Nunn-Lugar Program provide specific objectives for their individual programs. For the U.S. Department of Defense, CTR program objectives reflect the fact that Ukraine, Kazakhstan, and Belarus are non–nuclear weapons states. Nunn-Lugar is intended to: (1) assist Russia in accelerating strategic arms reductions to the second Strategic Arms Reduction Treaty (START II) levels; (2) enhance safety, security, control, accounting, and centralization of nuclear weapons and fissile material in the former Soviet Union to prevent their proliferation and encourage their reduction; (3) assist Ukraine and Kazakhstan to eliminate START II limited systems and weapons of mass destruction infrastructure; (4) assist the former Soviet Union to eliminate and prevent proliferation of biological and chemical weapons and associated capabilities; and (5) encourage military reductions and reform while reducing proliferation threats in the former Soviet Union.

The primary Department of Energy initiative dedicated to Nunn-Lugar work in Russia is the Material Protection, Control, and Accounting (MPC&A) Program. Its mission is to support U.S. national security objectives by enhancing the protection of international nuclear weapons and weapons-usable nuclear material at high risk of theft or diversion. The MPC&A Program's goals include assisting Russia and other nations in this endeavor, helping Russia to enhance its capabilities and commitment to operating and maintaining improved nuclear security, and establishing and maintaining a collaborative environment with MPC&A Program customers and stakeholders.

Whether coordinated by the U.S. Departments of Defense, Energy, or State, or by other U.S. government agencies, aspects of the Nunn-Lugar Program are negotiated, implemented, managed, and monitored through overarching "umbrella" agreements maintained between the United States and recipient governments that specify the rights and scope of the country-specific program. These agreements are set for a specific duration and include audit procedures. Separate implementing agreements are negotiated and maintained for each specific initiative. Congress authorizes each element of the program annually. The president annually certifies the eligibility of each recipient state for assistance against specified criteria required by Congress. U.S. agencies must notify Congress of their intent to commit funds to a specific country, and they must provide a full range of periodic reports about the program. The United States executes the program by providing goods and services, not aid. Audits of assistance provided ensure that goods and services are used in the manner specified by Congress.

Since the mid-1990s, the U.S. Congress has funded Nunn-Lugar at approximately $1 billion per year. Of that amount, the U.S. Departments of Defense and Energy are allocated about $400 million to $500 million each year, with the balance going to programs managed by other U.S. government agencies.

CTR Expansion Possibilities

Expansion of the Nunn-Lugar cooperative security model beyond the former Soviet Union holds tremendous promise for dealing with not only global chemical, biological, and nuclear threats such as fissile material stocks and infrastructure conversion but also for addressing a broad range of security issues. To do so, however, would require changes in the Nunn-Lugar legislation based on the lessons learned in the former Soviet Union as well as acceptance of the program by potential recipient states. Even if Congress passed legislation authorizing global application of Nunn-Lugar projects, it is unclear whether states with material at risk would be willing to participate. Furthermore, there are existing domestic and international legal constraints, including the 1946 Atomic Energy Act as modified in 1954 and Article 1 of the 1968 Nuclear Nonproliferation Treaty, on providing assistance to non–nuclear weapon states. Security and nonproliferation objectives, coupled with the unique benefits of the Nunn-Lugar process, however, might overcome these obstacles. Moreover, other important U.S. military and economic allies appear interested in providing international assistance to states seeking to rid themselves of dangerous chemical, biological, and nuclear weapons and infrastructure.

—Charles L. Thornton

See also: Arms Control; Russian Nuclear Weapons and Doctrine

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COORDINATING COMMITTEE FOR MULTILATERAL EXPORT CONTROLS (COCOM)

The Coordinating Committee for Multilateral Export Controls, or COCOM, was an international committee chartered to establish and coordinate restrictions for exporting technology to the Soviet Union and its allies. Established in 1949, members included Australia, Belgium, Canada, Denmark, France, Germany, Greece, Italy, Japan, Luxembourg, Netherlands, Norway, Portugal, Spain, Turkey, the United Kingdom, and the United States. Austria, Switzerland, and the Netherlands undertook varying degrees of participation in COCOM, although none of these states were official members. Headquartered in Paris, COCOM was not codified by treaty or international law. Rather, it made recommendations to member states by informal arrangement with no explicit enforcement mechanism to punish noncompliance.

COCOM established three separate lists of controlled items: the International Atomic Energy List, which restricted nuclear weapons technology; the International Munitions List, which restricted hardware and technology with direct military application; and the Industrial List, which restricted technologies with both a civilian and military use. Changes to these lists required unanimous consent from COCOM member states.

With the fall of the Eastern bloc and the collapse of the Soviet Union in the early 1990s, COCOM's original mission lost much of its relevance. In November 1993, members agreed to dismantle COCOM and replace it with an organization focused on nonproliferation strategies more suitable to the post–Cold War era. As a result, members began negotiating a successor to COCOM. The committee was officially disbanded on March 31, 1994, and replaced by the Wassenaar Arrangement in July 1996. During the interim period between COCOM and Wassenaar, many states continued to observe COCOM restrictions.

—Lawrence R. Fink

See also: Wassenaar Arrangement

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CORRELATION OF FORCES

During the Cold War, both Soviet and U.S. analysts and planners developed ways to measure the balance of strategic forces. U.S. planners tended to focus on quantitative measures of the strategic balance. For example, they counted the number of nuclear warheads and delivery systems deployed by both sides, estimated missile throw weight (the amount of payload that could be carried by either side's ballistic missiles), or determined the number of megatons and equivalent megatons that could be delivered by Soviet and U.S. nuclear forces. Various types of quantitative measures were then combined to develop politically and strategically meaningful estimates of each side's prompt hard-target kill capability or second-strike capability. U.S. concepts of arms race and crisis stability often emphasized quantitative measures of the strategic balance, even though politics and threat perception greatly influenced arms race and crisis stability (*see* Crisis Stability).

Soviet planners tended to take a broader view of the strategic nuclear balance than their American counterparts. In addition to these quantitative measures of the balance of strategic nuclear forces available to both sides, they incorporated many other kinds of qualitative and quantitative measures of the strategic situation in an effort to estimate the likelihood of war at any given moment. Their term for this measure—"correlation of forces"—incorporated estimates of political, social, moral, and economic trends. The correlation-of-forces method also took into account conventional military capabilities.

Many U.S. observers believed that Soviet efforts to measure the correlation of forces were superior to U.S. efforts to measure the strategic balance because it could yield not just a static snapshot but a comprehensive analysis of international trends. Because they were so comprehensive, however, correlation-of-forces estimates tended to be highly conservative. Thus, correlation-of-forces estimates never indicated to the Soviets that nuclear war was likely.

—James J. Wirtz

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COUNTERFORCE TARGETING

"Counterforce targeting" describes an attack against an opponent's military forces rather than against its civilian population. Such attacks would, in theory, allow nuclear war to be fought as limited war rather than as total war leading to the mutual annihilation of the parties involved in a conflict. By emphasizing counterforce rather than countervalue (urban-industrial) targeting, an incentive is given to the opponent not to conduct a countervalue attack in response to a counterforce strike. In reality, the proximity of military facilities to cities means that even a counterforce nuclear strategy would inevitably result in wide-scale devastation of urban areas. It may not be possible to fight such a limited nuclear war, and escalation to countervalue exchanges may be unavoidable.

Counterforce targeting was devised as a response to the problems associated with the decreasing credibility of the doctrine of "massive retaliation" in the face of growing Soviet nuclear capability, and increasing interest in the concept of limited war, that emerged in the 1950s. The shortcomings of massive retaliation were highlighted to the Dwight D. Eisenhower administration during the 1958 crisis with China over Quemoy and Matsu in the Taiwan Straits, when U.S. nuclear threats against China were deemed not to be credible. Four years later, the John F. Kennedy administration faced similar choices during the 1962 Cuban missile crisis, when an "all or nothing" nuclear strategy was seen to offer the National Command Authority (NCA) little flexibility for effective crisis management. Because a counterforce strategy could be undertaken more readily than a countervalue attack on cities, it might be more credible as a deterrent in the eyes of the opponent, and, failing that, offer the possibility that a nuclear war could be fought in a manner leading to some form of victory. Because nuclear war would be a "come as you are" conflict—the forces at hand being the only ones that would be used—if the opponent's forces could be eliminated by attacking first, then "victory" might be possible. Counterforce offered the prospect of damage limitation, while attacks on urban areas virtually guaranteed that the opponent would respond in kind. Counterforce attacks also were made possible by an increase in the number of nuclear warheads available for use. By 1966, the U.S. nuclear arsenal had peaked at 32,200 strategic and tactical warheads—clearly an arsenal far in excess of the one demanded by a countervalue strategy, since there were only some 200 Soviet cities large enough to warrant being targeted. The large number of warheads available opened up a wide array of targeting options beyond "city busting."

As Soviet nuclear capabilities improved and parity with the United States was established in the 1970s, it became clear that a counterforce nuclear strategy offered the United States the most credible deterrent in the face of a Soviet nuclear threat. Counterforce-orientated nuclear strategy has dominated U.S. nuclear thinking ever since and was reflected in the different versions of the Single Integrated Operational Plan (SIOP) that were developed during the latter half of the Cold War.

With the fall of the Soviet Union in December 1991, U.S. nuclear strategy continued to emphasize counterforce rather than countervalue targeting. Although U.S. and Russian strategic nuclear forces are officially "detargeted," reducing the danger posed by an accidental missile launch, both sides can quickly reenter targets into the guidance systems of their weapons. The Nuclear Posture Review (NPR), which was submitted to Congress on December 31, 2001, embraces the notion of limited nuclear war and counterforce targeting and includes nonnuclear strikes and strategic information warfare (SIW) as part of U.S. strategic deterrent capabilities. This means that the United States would be less dependent on large-scale use of nuclear weapons in a crisis, even against a nuclear-armed state such as Russia or China.

The United States no longer plans its nuclear arsenal purely on the basis of targeting the Russian Federation. Targeting of nuclear weapons will be based on the nature of the threat or the nature of the target being destroyed using adaptive, capabilities-based planning, which will replace the deliberate planning process used to create the SIOP. Although the components of the old "Triad" of nuclear delivery systems (intercontinental ballistic missiles [ICBMs], submarine-launched ballistic missiles [SLBMs], and manned bombers) will remain (though at significantly reduced numbers, and in some cases at reduced alert levels), new nuclear capabilities more suited to dealing with twenty-first-century security challenges may be developed, including very low-yield "mini-nukes" to attack hard and deeply buried targets (HDBTs) such as command and control bunkers and chemical and biological weapons laboratories.

Although there is no longer an emphasis on preparing to fight a major nuclear war, U.S. planners have identified a need to maintain credible warfighting options as the basis of deterrence. Counterforce targeting, as a guiding principle of nuclear war planning, continues to remain attractive today.

—*Malcolm Davis*

See also: City Avoidance; Cold War; Countervalue Targeting

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COUNTERMEASURES

To counter antiballistic missile (ABM) systems and confuse radars and telemetry sensors, intercontinental ballistic missile (ICBM) warhead buses are equipped with devices called "penetration aids" to help warheads evade detection by radar and blast from ABM systems. These measures are meant to counter an adversary's ability to stop a missile from reaching its target. The concept is to overwhelm both the ground-based radars guiding the antiballistic missile systems and the seekers in the individual antiballistic missiles. To overcome the initial Soviet ABM system deployed around Moscow in the 1970s, for example, the United States MIRVed (that is, incorporated multiple independently targetable reentry vehicles as a weapons payload) its ICBMs and submarine-launched ballistic missiles (SLBMs). The number of warheads exceeded the number of interceptor missiles available to the Soviet ABM system.

Using radar-absorbing materials on the reentry vehicles (RV), booster fragmentation, jammers, metallic chaff, or aluminum balloons prevents the enemy from detecting or destroying RVs. Other techniques are spin stabilizing the RV, reorienting the RV, and separating the RV from the bus and providing it with its own aerodynamic or rocket-propulsion system. The last technique can become too expensive if an exact replica of the RV has to be built. By using atmospheric screening, all decoys and false RVs will burn up on reentry, allowing antiballistic missiles to recognize and strike the remaining warheads inside the Earth's atmosphere. A two-tiered approach to defense to defeat most of these penetration aids in space requires the design of weapons with a seeker that can discriminate between the false and real RV.

The ultimate way to overcome ABM systems came with the development of RVs that could fly different flight profiles. The Soviet Union attempted to give its warheads aerodynamic features that allowed them to maneuver while in terminal reentry phase. Rocket thrusters, or motors fitted to individual warheads, also would constitute a countermeasure. New materials technology has led to the development of other countermeasures. The debate about countermeasures has reemerged with the planned U.S. deployment of an antiballistic missile system.

—Gilles Van Nederveen

See also: Missile Defense; Moscow Antiballistic Missile System; Penetration Aids

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COUNTERPROLIFERATION

"Counterproliferation" refers to the full range of military preparations and activities conducted to reduce and protect against the threat posed by nuclear, biological, and chemical (NBC) weapons and their associated delivery systems. Counterproliferation (CP) is a multitiered effort and enables U.S. forces to survive, fight, and win in an NBC environment. It is enhanced by proliferation prevention and military support to nonproliferation efforts. In CP operations, a sequence of mutually supporting, offensive and defensive measures form a continuum of interrelated activities built on six core capabilities or principles: prevention, deterrence, counterforce, active defense, passive defense, and consequence management. The success or failure of efforts in one area impacts other functions throughout the operational cycle.

Proliferation prevention includes those actions taken to deny attempts by would-be proliferants to acquire or expand their NBC capabilities by providing inspection, monitoring, verification, and enforcement support for nonproliferation treaties and NBC arms control regimes; supporting export-control activities; assisting in the identification of potential proliferants before they can acquire or expand their NBC capabilities; and, if so directed by the National Command Authority, planning and conducting denial operations.

Deterrence involves a state of mind in the opponent brought about by the existence of a credible threat of unacceptable counteraction; that is, it is the prevention of military action through fear of the consequences (*see* Deterrence).

The objective of counterforce is to eliminate an adversary's NBC capability. Counterforce operations can be conducted as joint strategic attack, special operations, nuclear operations, and offensive counter air. Key operational considerations for counterforce operations include joint intelligence preparation of the battlespace; battle management; targeting; and battle damage assessment.

The objective of active defense is to eliminate an incoming NBC threat. Active defense operations can be conducted against aircraft, ballistic and cruise missiles, rockets, long-range artillery, submarines, surface vessels, special operations forces, and terrorists. Key operational considerations for active defense operations include detection; warning, identification, and reporting; tracking; engagement; and assessment. Counterforce operations and active defense probably would be employed together to lessen the number of attacks friendly forces have to absorb and to reduce the burden on passive defense measures.

Passive defense is the protection of personnel and facilities from the effects of NBC attack to sustain operations. The objective is to minimize the loss of operational capability caused by an enemy use of NBC weapons. Passive defense focuses on mission continuation while providing for force survivability. Key operational considerations include vulnerability analysis; attack warning and threat assessment; detection and identification; contamination avoidance; individual and collective protection; and contamination control.

The objective of consequence management is to mitigate the long-term effects of an attack and enable a return to operational capability. It can be performed in a military context whereby decontamination and cleanup allows a return to full, normal operations. It can also be performed as military support to foreign or domestic civil authorities.

—Jeffrey A. Adams

See also: Nonproliferation; Proliferation

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COUNTERVAILING STRATEGY

Upon taking office in 1976, President Jimmy Carter ordered a review of U.S. nuclear weapons policy under Presidential Directive 18 (PD-18). The review resulted in a new concept known as "countervailance," which was designed to ensure that "no plausible outcome of a Soviet nuclear attack would represent a success or any rational definition of a success." What would eventually result would be a wider range of nuclear options that the president and the National Command Authority (NCA) could choose from under Presidential Directive 59. PD-59 and countervailance took the notion of "flexible response" to perhaps its ultimate level during the Cold War. The Ronald Reagan administration then reaffirmed the concept of countervailance in National Security Decision Memorandum 13, issued in October 1981, which emphasized the importance of command and control, survivable postattack forces, and greater coordination between strategic and theater nuclear forces.

The emergence of a countervailing strategy really began with a desire by U.S. decision makers to find a way out of the situation of mutual assured destruction (MAD) brought about by nuclear parity in warheads and delivery systems achieved by the Soviet Union in the late 1960s. Henry Kissinger, U.S. secretary of state under Richard Nixon, asked, in a report to Congress in February 1970, "Should a President, in the event of a nuclear attack, be left with the single option of ordering the mass destruction of enemy civilians, in the face of the certainty that it would be followed by the mass slaughter of Americans?" Kissinger's question highlighted the need for nuclear forces and capabilities that offered credible deterrent options proportionate to the level of provocation. Even with the move away from reliance on countervalue in the mid-1960s, the options open to the president still emphasized large-scale counterforce attacks, many of which would also be directed at counterforce targets located within or near urban areas. There was little in the way of thinking about selective or limited nuclear strikes on specific targets, small-scale nuclear exchanges, or demonstration attacks. There was also growing concern over the potential ability for the Soviet Union to remove or significantly reduce the U.S. counterforce capability, which rested primarily with the Minuteman intercontinental ballistic missile (ICBM) force.

The Schlesinger Doctrine emerged in 1974 from a desire expressed by Kissinger in 1970 to offer the president a wider range of options than that offered under MAD. James Schlesinger's belief in a wide range of options for the employment of nuclear weapons, with an emphasis on developing capabilities for smaller, selective strikes, would lay the groundwork for President Carter's defense secretary, Harold Brown, to argue for a posture of countervailance in 1979. Central to both the Schlesinger Doctrine and countervailance theory was a belief that nuclear war could be fought at a lower level than what was envisaged under MAD. In effect, the war could be limited and controlled by both sides.

The key challenge to both concepts was ensuring Soviet compliance with the same doctrine. Documentary evidence of the period indicated that rather than embracing limited options, Soviet thinking about nuclear war still emphasized large-scale nuclear offensives against both counterforce and countervalue targets. This was particularly the case within the European theater of operations, in which the first use of nuclear forces by either side would see an order of magnitude shift in the conflict, with nuclear weapons employed fully and comprehensively to destroy enemy forces.

Given the challenge of uncertainty about Soviet thinking on nuclear war, the 1979 countervailing doctrine sought to emphasize escalation dominance, ensuring that the Soviet Union realized that no matter what level of nuclear force was used, the United States would prevail through effective command and control, survivable delivery systems, and an ability to maintain operational flexibility under any circumstances. Most significantly, countervailance sought to ensure the ability to wage a protracted, limited nuclear war, possibly lasting up to two months, rather than the short spasm exchange considered by earlier countervalue and counterforce concepts. A range of new target options would emerge with countervailance, including the Soviet command structure and political leadership, its nonnuclear forces, and its economic and industrial base. Furthermore, the importance of countervalue strikes was considered, and a survivable second- or third-strike strategic reserve was seen as vital.

—Malcolm Davis

See also: Cold War; Flexible Response; United States Nuclear Forces and Doctrine

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COUNTERVALUE TARGETING

Countervalue targeting is the use of nuclear weapons against targets of high value to the adversary, in particular urban areas, key industrial sites, leadership, or government facilities. Countervalue targeting is thus differentiated from counterforce targeting, which is directed against an adversary's military capabilities, especially its strategic nuclear forces and associated command and control systems.

During the early Cold War, U.S. nuclear policy emphasized countervalue rather than counterforce targeting, and it was not until the 1960s that counterforce targeting assumed predominance. The limited number of nuclear weapons available for use until the mid-1950s, and the challenges in delivering those weapons onto a target via manned bombers in the face of Soviet air defenses, made it difficult to target anything but large urban areas.

Doubts about the credibility of deterrent threats drove debate about the desirability of countervalue targeting. With Soviet advances in nuclear delivery systems and the gradual expansion of the destructive power of the Soviet nuclear arsenal, there was less confidence that the United States would be safe from Soviet nuclear retaliation if nuclear war occurred. A nuclear strategy that emphasized attacks on urban areas might lead to a Soviet retaliation against urban-industrial targets, leaving the United States devastated in the aftermath of a countervalue nuclear exchange. The impact of the Cuban missile crisis, the growing popularity of notions of limited war, and improvements in the accuracy and responsiveness of intercontinental ballistic missiles (ICBMs) and nuclear-armed long-range bombers meant that countervalue targeting would soon give way to a more flexible deterrent posture based around limited nuclear options and counterforce targeting.

Countervalue targeting did not completely disappear from U.S. nuclear strategy in the second half of the Cold War. Until the deployment of the Trident D5 submarine-launched ballistic missile (SLBM) in the late 1970s, the submarine-based leg of the U.S. nuclear "Triad" (ICBMs, SLBMs, and manned bombers) lacked the hard-target kill capability (a combination of accuracy and yield) of land-based ICBMs, and thus SLBMs were aimed either at soft targets (airbases and ports) or countervalue targets (cities). Furthermore, many command and control targets existed within Soviet cities, meaning that even a counterforce attack would inevitably see such cities devastated and would almost certainly result in a Soviet countervalue response against U.S. cities.

It is extremely unlikely that the United States or the Russian Federation would return to countervalue targeting today. Although both sides maintain substantial nuclear arsenals as an insurance against an unforeseen crisis, the United States no longer bases its nuclear war planning on responding to a signal Russian threat. With new strategic nonnuclear strike options, U.S. officials now concentrate on ways to disarm opponents that possess small nuclear, chemical, and biological weapons arsenals.

The same cannot be said necessarily for other emerging nuclear weapons states, which still perceive utility in targeting cities to coerce or deter opponents. A second-strike deterrent capability, such as that being pursued by India, is most effective if it is aimed at cities, especially given that Indian military doctrine suggests that nonnuclear forces would preemptively launch counterforce attacks on an adversary's nuclear forces. Pakistan's nuclear strategy seems to be designed as a deterrent against an Indian conventional attack. India's reliance on a nonnuclear counterforce attack at the outset of any conflict with Pakistan increases the risk of nuclear escalation in a full-scale conventional war with Pakistan, especially if Pakistani officials face a "use it or lose it" predicament.

It is difficult to predict or even determine the employment doctrine of most states. The smaller the number of deliverable warheads available, the greater the likelihood that the state will adopt countervalue targeting. Thus, states such as Iran and North Korea, both of which are pursuing nuclear weapons capabilities, may rely heavily on threatening a few key urban areas within range of their limited number of missiles rather than seeking to develop complex and costly counterforce capabilities.

—Malcolm Davis

See also: Counterforce Targeting; Deterrence; Massive Retaliation

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COUPLING

The term "coupling" often refers to a mechanical device that unites two things. In nuclear strategy, it refers to the linking of issues, and during the Cold War it was used to describe the United States' nuclear guarantee to Western Europe and other U.S. strategic partners.

Article 5 of the Charter of the North Atlantic Treaty refers to the idea that an attack on any North Atlantic Treaty Organization (NATO) state would be considered an attack on all the members of NATO. This charter committed the United States and Canada to the defense of Europe, especially against the perceived threat posed by the Soviet Union. For much of NATO's history, the alliance relied on the deterrent provided by U.S. nuclear forces to offset the conventional superiority of the Soviet Union. It was this "coupling" of the U.S. strategic nuclear deterrent to the defense of Western Europe that became a principal focus of concern for policymakers, especially once the situation of mutual assured destruction (MAD) emerged between the United States and the Soviet Union. Analysts debated whether the U.S. nuclear guarantee was credible, given the likely Soviet response if the United States chose to use nuclear weapons against Russia in the defense of Western Europe. Concerns about decoupling the U.S. strategic nuclear force from the defense of NATO was often used as a justification for the U.S. decision to launch the Strategic Defense Initiative (SDI) in 1983, and for the 1979 decision to modernize NATO's theater nuclear forces in the 1970s. Earlier debates about the credibility of NATO's policy of massive retaliation and the shift to flexible response in 1967 also were in part a response to the credibility of U.S. extended deterrence and the coupling of U.S. nuclear forces to the defense of NATO.

—Andrew M. Dorman

See also: North Atlantic Treaty Organization (NATO)

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Representatives from twelve nations convene in Washington, D.C., on April 4, 1949, to sign the North Atlantic Treaty, which coupled the defense of Western Europe and North America. (NATO Photos)

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CREDIBILITY

The issue of credibility has long been associated with nuclear weapons. For strategists and policymakers, doubts always existed about whether a rational decision could ever be made to use nuclear weapons. Thus, nuclear threats, especially against similarly armed opponents, appeared to lack credibility; nuclear use could be tantamount to national suicide. To many it seemed that only when the very survival of the state itself was threatened did nuclear threats become credible. This was one of the main criticisms of the concept of massive retaliation, a U.S. declaratory policy early in the Cold War that suggested that minor Soviet military operations might be met with a massive U.S. nuclear response.

Many observers also believed that policies of extended deterrence—in which the United States threatened to employ its strategic nuclear arsenal in defense of Western Europe—were not credible. Once the Soviet Union had achieved an assured second-strike capability, the U.S. threat to initiate nuclear hostilities in the event of a Soviet invasion of Europe appeared to many to lack credibility. Frequently the argument was put in terms of whether the United States would be prepared to sacrifice New York and Washington for London and Paris.

Today, many observers believe that nuclear threats lack credibility because most military threats are minor and the destructive power of existing nuclear forces is extraordinarily large. Because the use of nuclear weapons would be viewed as a disproportionate response to all but the most devastating attacks, threats to use nuclear weapons are viewed by friend and foe alike as lacking credibility.

—Andrew M. Dorman

See also: Deterrence; Massive Retaliation

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CRISIS STABILITY

The first half of the twentieth century saw two devastating world wars, the onset of the nuclear age, and the emergence of weapons of mass destruction, leading the political scientist Raymond Aron to call it "the century of total war" (Aron). Bernard Brodie, in his 1946 classic *The Absolute Weapon,* described what became axiomatic for how much of the world looked at war and peace: "Thus far the chief purpose of our military establishment has been to *win* wars. From now on its chief purpose must be to *avert* them. It can have almost no other useful purpose" (Brodie, p. 77). This so-called "nuclear revolution" changed the very purpose of military forces from winning to preventing the outbreak of wars in the first place.

This focus on deterring rather than fighting major wars spawned a whole body of literature dealing with the requirements of deterrence, especially the prospective use of nuclear weapons. These theorists suggested that the strategic antagonists—notably the United States and the Soviet Union—would be locked in a long-term competition. Conflict was not likely to be *resolved;* therefore, it had to be *managed*—the relationship had to be *stable* in the sense that neither side had an incentive to use nuclear weapons first in a crisis.

A stable strategic relationship is one that is not easily disturbed by new or changing circumstances. It is a relative concept—a more stable relationship is more resilient in the face of new pressures; a less stable relationship is one in which the perception of changing risks or opportunities is more likely to lead to changed behavior that alters the character of the relationship. Assessing whether deterrence is likely to succeed requires an assessment not only of one's capability and will to make good on one's deterrent threats, but also of how the other *perceives* whether it is in its interests *not* to provoke a war—not only during normal circumstances, but also in a crisis, when it might calculate its interests, risks, and opportunities differently.

For a strategic relationship to possess crisis stability, it should not promote incentives during a crisis for either side to initiate conflict or challenge the position of the other in a way that would provoke conflict. For example, there might not be any incentive for a state to go to war during normal circumstances—peace, even with the tensions of the Cold War, would be preferable to war. However, rising political tensions might cause a state to conclude that war is likely, that it faces a higher risk of being attacked itself, and that there are advantages to attacking first if war were to occur. In such circumstances, a normally stable relationship would be unstable in a crisis.

The circumstances that would jeopardize crisis stability typically involve some combination of *vulnerability* and *opportunity*—that is, situations where the state sees an opportunity to reduce its own vulnerability by taking advantage of an opponent's weakness. During the Cold War and beyond, improving crisis stability encouraged policy choices that sometimes involved not only increasing the survivability of one's nuclear forces, but taking steps to increase the survivability of a potential adversary's nuclear forces. If both sides in a dispute possessed a secure second-strike capability, then neither would feel much incentive to use nuclear forces first in a crisis.

For example, the dominant characteristic of the missile age has been the lack of adequate defense against attack. Such vulnerability means that the only way to avoid unacceptable destruction in a war is to destroy the opponent's attack capability. During the late 1950s and early 1960s, both the United States and the Soviet Union possessed ballistic missiles that were themselves vulnerable to attack; thus each had an opportunity to destroy that threat before being attacked by launching a nuclear attack first in the hope of catching the opponent's nuclear arsenal on the ground. In a crisis, each would have had an incentive to strike first, in the hopes of eliminating a substantial portion of the missiles against which it could not defend, rather than waiting to be attacked.

By contrast, if the missiles in question were protected, then the opportunity to defeat the threat posed by those missiles disappears. In the early 1960s, the United States not only began to put its intercontinental ballistic missiles in underground silos but also encouraged the Soviet Union to do the same. By placing their missiles in silos, both sides increased the survivability of their retaliatory capability.

Preserving crisis stability was likewise the rationale for urging—as the United States did in the late 1960s and early 1970s—that both superpowers forgo building national ballistic missile defenses. With no ability to reduce society's vulnerability to destruction, and no guarantee that a first strike would succeed (that is, result in total destruction of the opponent's nuclear arsenal), crisis stability was enhanced, at least in theory. In short, vulnerable societies and invulnerable retaliatory capabilities—the elements of mutual assured destruction (MAD)—constituted the formula for a stable deterrent relationship.

Improvements in military technology did not allow such a simple formula to endure. By the 1970s, larger nuclear arsenals, plus the ability to destroy even hardened military targets, meant that retaliatory capabilities were increasingly vulnerable and therefore lucrative targets for preemption. This new reality, in turn, prompted renewed interest in national missile defense as a way of removing the vulnerability of both strike forces and society at large.

Even after the Cold War ended, this debate continued. Critics of national missile defense—including the Russian government—argued that a one-sided development of such defenses would create first-strike incentives in a crisis. The only way to improve crisis stability would be to develop missile defenses jointly.

Because crisis stability largely depends on how states perceive threats, risks, opportunities, and incentives, mechanisms to improve communication in a crisis also have been important—beginning with the Hot Line Agreements from the early 1960s and continuing with the more recent exchange of military personnel in strategic command and warning centers. Beyond the bilateral nuclear relationship, provisions to improve communication and avoid miscalculation in a crisis have become standard elements in managing conflict situations around the world.

Crisis stability is ultimately about keeping all parties in an antagonistic relationship believing that they are secure even if the threat of war increases. This involves efforts to reduce the incentives of all parties to use nuclear weapons first in a crisis. Paradoxically, this means that a larger military capability may be more stabilizing than a smaller one, if the smaller one is more vulnerable to being destroyed in a surprise attack. Hence, the pursuit of crisis stability in a deterrent relationship may be at odds with the purposes of disarmament.

—Schuyler Foerster

See also: Deterrence; Disarmament; Downloading; Escalation; Firebreaks; Mutual Assured Destruction; Survivability

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CRITICAL NUCLEAR WEAPONS DESIGN INFORMATION (CNWDI)

Critical Nuclear Weapons Design Information (CNWDI) is information classified as "top secret" or "secret" relating to the theory of operation, design, and function of nuclear weapons. This information covers overall weapon design, weapon component, and subassembly data. Other information may relate to fusing and arming nuclear weapons or to the material composition of the weapons and the quantities of special materials incorporated into them. Security functions such as a permissive action link (PAL), a lock that prevents unauthorized use of a nuclear weapon, may also have a CNWDI restriction.

This level of security clearance is required for persons with access to weapons, plans, weapons labs, or forums discussing this information. Security managers at specific locations can verify current clearance levels and clear individuals for CNWDI as needed.

—Bret Kinman

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U.S. Department of Defense website, http://www.defenselink.mil.

CRITICALITY AND CRITICAL MASS

The key requirement for making a nuclear weapon or a practical nuclear reactor is to create a self-sustaining chain reaction. In such a chain reaction, neutrons released by fission in one atom are likely, on average, to induce the fission of one or more subsequent atoms. An assembly of fissile and other materials that can support a self-sustaining chain reaction is said to be a "critical" assembly or to have achieved "criticality."

Criticality depends on the type and amount of fissile material as well as on assembly details such as mass, surface area, geometry, and the composition of nonfissionable materials used in construction. The primary criterion for criticality is that the multiplication factor (k)—the ratio of neutrons in one generation of fissions to the number produced in the final generation—be greater than unity. The $k > 1$ criterion is a primary design consideration for any practical use of nuclear energy and is achieved by creating designs that balance the production and loss rate of neutrons. The criticality condition can be met with a variety of assembly structures, sizes, and time scales; can be exceeded significantly or barely met; and can be met with different fissionable materials that produce combinations of fast and slow neutrons. The most significant differences in design of nuclear assemblies are between nuclear weapons and nuclear reactors.

Criticality in Nuclear Weapons

A nuclear weapon explodes because the assembly is designed to release energy from a fission chain reaction so quickly that the fissile material vaporizes. If two subcritical assemblies ($k < 1$) are brought together too slowly, they will release heat and melt rather than produce an explosion. A nuclear weapon requires an explosive assembly that goes quickly from a subcritical state to a supercritical state ($k \sim 2$: On average, neutrons from any single fission event are likely to produce two subsequent fissions).

Once assembled into the supercritical state, the chain reaction can only occur for a brief moment because criticality causes the fissile material to blow itself apart. But the time scale between fissions in a critical assembly is about ten nanoseconds; for $k \sim 2$, all the atoms in a kilogram of uranium would completely fission in less than a microsecond. The nuclear energy released from the complete fission of one kilogram of uranium would be equivalent to the energy released from about 17,000 kilograms of chemical explosives.

Shape has a major impact on the size and mass required for a critical assembly. A long, thin rod, with a large surface area, would lose many neutrons through the surface before they could participate in a chain reaction. The optimum shape for achieving a critical assembly with the smallest possible mass is a sphere; the number of fissionable atoms increases with the cube of the radius, but the surface area for escaping neutrons increases only with the square of the radius. Not all nuclear weapons use spherical assemblies, but early nuclear weapons depended on this optimum shape.

For nuclear weapons, the timing of achieving criticality is very important. The weapon works best if the assembly goes from subcritical to supercritical instantaneously. If subcritical assemblies come together very slowly, fission energy will be dissipated in heating the materials, possibly moving them out of an appropriate shape to sustain criticality. The spontaneous fissions from uranium or plutonium also can initiate a chain reaction before supercriticality is achieved. Such a premature chain reaction would not use up much of the fissile material, would dramatically reduce the nuclear yield, and would be referred to as a "fizzle."

The term "critical mass" is something of a misnomer. Achieving criticality depends upon the density, configuration, and timing of a nuclear weapon assembly, and only partly on the total mass of fissile material available to participate in the chain reaction; there is no single "critical mass" used to construct a nuclear weapon. The amount of fissile material used in a nuclear weapon depends on the yield sought, the assembly design and configuration, and the predicted fraction of the nuclear material that will generate the explosion before being explosively disassembled.

Nonetheless, it is common to speak of the critical mass for the primary fissile materials in a particular assembly. In many unclassified books and articles, it is common to see a single number quoted as "the critical mass" for uranium 235 (usually quoted as a number between about 9 and 25 kg) or plutonium 239 (usually between 4 and 20 kg). These different numbers reflect different assumptions about the assembly requirements needed to construct explosive devices. Efficient designs, involving spheres of pure material and surrounding the nuclear assembly with materials that reflect neutrons and delay the dispersion of explosive products, require less fissile material. Conservative designs use extra material to ensure that supercritical conditions are met and to make up for uncertainty in the fraction of nuclear material that might be involved in the explosive chain reaction.

There are significant differences when it comes to using fissile uranium and plutonium in designing a nuclear weapon. Plutonium is a denser material, and a smaller amount of plutonium will usually be required to produce a given yield from a particular design. Variations in isotopic content and metallurgic mixture, however, can overwhelm this difference in density. The spontaneous fission rate for plutonium (and especially of the isotope Pu-240) also is much higher than the spontaneous fission rate of uranium. Because of this higher rate of spontaneous neutron generation, plutonium weapons need to be assembled rapidly to avoid premature fizzle yields.

Weapon designers consider a design to have fizzled when only a small amount of the fissile material is consumed in a chain reaction. It is important that weapon designs make efficient use of fissile plutonium or uranium because the cost and effort involved in producing these materials is high. Given the resources put into creating a nuclear weapon, it is not cost-effective unless it is much more powerful than a conventional high-explosive device. This was a major concern on the part of scientists working on the Manhattan Project during World War II. The mass of the hardware needed to make a nuclear weapon dwarfs that of the fissile material itself; for example, the nuclear weapon dropped on Nagasaki weighed about 10,000 pounds but used only 10 to 20 pounds of plutonium (*see* Manhattan Project).

A nuclear "dud" can be caused by a variety of miscalculations or malfunctions. Similarly, it is difficult to predict the exact yield of a nuclear weapon. In the extreme case, assembly time might be so slow that plutonium might begin to melt into a new shape and never achieve a significant nuclear yield. But a fizzle—an extremely inefficient nuclear weapon—may still produce a large explosion and many deaths. The uranium bomb dropped on Hiroshima was inefficient and is believed to have created a chain reaction in only about 1 or 2 percent of the 140 pounds of highly enriched uranium in its nuclear assembly. But the yield of this weapon was equivalent to between 10,000 and 15,000 tons of TNT—2,000 times greater than the blast effect that would have been produced by 10,000 pounds of TNT. It instantly killed between 70,000 and 130,000 people. New nuclear powers and terrorists may be satisfied with very inefficient nuclear weapons if the yield is large enough, and they may tolerate great uncertainties in the percentage of fuel contributing to the explosion (*see* Fission Weapons; Gun-Type Devices; Implosion Devices; Plutonium; Uranium).

Criticality in Nuclear Power Production

A nuclear reactor also depends on the property of criticality. A practical reactor, used to generate electric power, must maintain a chain reaction to take more energy out than is being used to operate the reactor. Nuclear reactors are usually designed to operate with k near unity. Reactor design balances the loss of neutrons through the surface and by absorption in nonfissile materials (including the coolant that captures the energy for electricity generation) with the generation of many neutrons from a chain reaction in a large amount of fissile material. The fuel rods of nuclear reactors tend to have large surface areas, and the total amount of nuclear fuel used in a single critical assembly is typically measured in tons. The reactor consists of an assembly of fissile material, moderators to slow the neutrons and increase the likelihood of fission, control elements that can absorb neutrons and decrease the likelihood of fission, coolant to take away the heat generated by absorption of neutrons, and other elements as required. Varying the position of control elements and the rate of coolant flow allows the reactor to be operated in a self-sustaining chain reaction or maintained at a subcritical level.

The relatively low multiplication factor in a reactor design means that nuclear energy is released at a much lower rate than in a nuclear explosion. The nuclear energy generated by fission is released over a much larger period of time than in a nuclear weapon. At $k = 1$, a kilogram of uranium atoms takes decades to completely fission. The same factors that determine criticality in a nuclear weapon—total amount of fissionable material, density, configuration, and timing—are managed in a nuclear reactor design. But the reactor design creates a barely sustained chain reaction, with the percentage of fissile material participating in the chain reaction during each second very low (approximately 10^{-14} percent). A high total power level is achieved by arranging large amounts of fissionable materials into a nuclear assembly participating in the chain reaction.

The level of criticality and the kind of chain reaction that occurs is determined by the design of a nuclear assembly. A fast assembly cannot be used to produce a sustained power generation over a long period of time, and a distributed nuclear reactor cannot be made to explode. Even an uncontrolled chain reaction allowed to operate well outside design parameters in a nuclear reactor would lead only to the melting of the fissile materials and a drop below criticality (*see* Reactor Operations).

—*Roy Pettis*

See also: Fission Weapons; Thermonuclear Bomb

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CRUISE MISSILES

The cruise missile has been defined as "an unmanned self-propelled guided vehicle that sustains flight through aerodynamic lift for most of its flight path and whose primary mission is to place an ordnance or special payload on a target" (Werrell, p. 223). Cruise missiles can be divided into two main categories: unmanned air vehicles (UAVs) and unmanned combat air vehicles (UCAVs), which are essentially UAVs that carry ordnance. The United States introduced a fleet of air-launched cruise missiles (ALCMs), submarine-launched (or surface ship–launched) cruise missiles (SLCMs), and ground-launched cruise missiles (GLCMs) in 1974, all of which are experiencing a contemporary resurgence in military operations. Cruise missiles were first used in combat during World War II. The most famous version of this type of weapon was Nazi Germany's V-1, or "buzz bomb." Inexpensive to produce, early postwar cruise missiles utilized aircraft fuselages and jet engine technology and carried nuclear warheads in the megaton range to compensate for their limited accuracy.

Two technical breakthroughs in the early 1970s transformed the cruise missile into a highly lethal weapon system. The first breakthrough was produced by the dramatic reduction in the size of computers coupled with equally dramatic increases in the computational capabilities of on-board computer guidance systems. These sophisticated guidance systems enabled cruise missiles to fly preprogrammed flight paths at very low altitudes, making them difficult to detect. The second breakthrough, advances in jet propulsion, allowed engineers to decrease the size of the missiles while increasing their range and payload. Equipped with a new navigation system called terrain contour matching (TERCOM), which allowed the missiles to follow preprogrammed terrain maps on the way to their targets, U.S. cruise missiles achieved extremely high accuracies. Newer generations of cruise missiles rely on global positioning system (GPS) signals to achieve high accuracy without the need for the TERCOM maps (which are expensive and time consuming to create).

Cruise missiles require several subsystems: airframe, propulsion, guidance, control and navigation, and weapons integration. None of these systems is extraordinarily expensive, and the decreasing price and increasing capability of modern guidance systems promises to reduce the price tag of cruise missiles in the future. The survivability and cost-effectiveness of cruise missiles influenced President Jimmy Carter's decision to cancel the B-1 bomber in 1977 and to use cruise missiles to extend the life of the B-52 force as part of the airborne leg of the U.S. nuclear "Triad" (intercontinental ballistic missiles [ICBMs], submarine-launched ballistic missiles [SLBMs], and manned bombers).

ALCMs improved the ability of manned bombers to strike multiple targets from a safe standoff range. Cruise missiles thus make a unique

Test flight of a Tomahawk cruise missile, used by U.S. and British naval forces. (Raytheon/Reuters/Corbis)

contribution to aircraft effectiveness and survivability. Older bombers can become a first-class strategic threat—witness the USAF B-52 and the Russian Bear-H. The Soviets spent a good part of the Strategic Arms Limitation Talks (SALT II, 1979) attempting to limit the deployment and range of the new American cruise missiles. Bombers carrying the cruise missiles were actually counted against MIRVed weapon sublimits in these arms control agreements. The first Boeing AGM-86 ALCM was deployed on a B-52G at Griffiss AFB, New York, in January 1981; it was added to the B-52H in 1985. After Desert Storm in 1991, the U.S. Air Force requested money to begin reequipping the ALCM with conventional warheads. This became the conventional ALCM, or CALCM AGM-86C/D. It was used for the first time against Iraq in Desert Fox in 1996. At first the CALCMs were simply converted nuclear ALCMs. The U.S. Air Force has since reopened the production line to produce more CALCMs outfitted with both a hard-target penetrator and a submunitions dispenser warhead.

The U.S. Navy also developed a cruise missile for its submarines and ships. The submarine-launched version was kept in a capsule and launched from one of the submarine's torpedo tubes. Later, Los Angeles–class attack submarines were fitted with vertical launch tubes outside of the pressure hull, saving valuable on-board space for torpedoes and other weapons. The U.S. Navy's Tomahawks (also known as Tomahawk land-attack missiles, or TLAMs) were fired extensively during Operation Desert Storm, and again during Allied Force (Kosovo, 1999), Enduring Freedom (Afghanistan, 2001), and Iraqi Freedom (2003), attacking a variety of targets. Their conventional warhead limited their utility against hardened targets, but upgrades are improving the lethality of the Tomahawk. The U.S. Navy has approximately 120 vessels from which it can be launched. The TLAM became the first cruise missile system sold to a foreign country when, in 1996, the Royal Navy added the weapon to its inventory, initially carrying the Tomahawk on attack submarines. The first combat employment of the TLAM by the Royal Navy occurred during Operation Allied Force against Serbia. The U.S. Navy was able to increase its deployment flexibility when the weapon was certified for use in vertical launch arrays emplaced on modern cruisers and destroyers.

As the Soviet Union reequipped and expanded its theater nuclear capabilities in the 1970s with the SS-20 intermediate-range ballistic missile, NATO decided to challenge the deployments with its own intermediate-range nuclear weapons, one of which was the ground-launched cruise missile. Using the Tomahawk cruise missile mounted on a flatbed trailer in four round armored box launchers, 464 cruise missiles were deployed to Western Europe in quick reaction alert. This class of cruise missile was eliminated by the Intermediate-Range Nuclear Forces (INF) Treaty of 1987 (*see* Intermediate-Range Nuclear Forces [INF] Treaty).

The Soviet Union had developed its own family of cruise missiles by 1986. The AS-15 Kent is an ALCM carried by both the Bear-H and Blackjack bombers. The SS-N-21 was the SLCM deployed on Victor-, Akuala-, and Sierra-class attack submarines. Other submarines, such as the Oscar guided-missile submarines, also carried these cruise missiles. A Soviet GLCM, the SSC-X-4, was banned under the INF Treaty.

As the first of the stockpile of about 1,600 ALCMs were converted to conventional explosive warheads, the U.S. Air Force developed a new stealth cruise missile for the nuclear strike mission. The AGM-129 Advanced Cruise Missile purchase was completed in 1999. Success in Desert Storm, and the availability of navigational satellite systems, led to the proliferation of cruise missiles, which now could be placed into two categories: land-attack cruise missiles and antishipping cruise missiles. Only France, Russia, Great Britain, and the United States possessed land-attack cruise missiles in 2004. Antishipping cruise missiles are manufactured and exported to a wider network of countries. Some can be modified to attack land targets, but most lack the range to carry out deep-strike missions. Among the best known is the French Exocet antishipping missile.

Cruise missiles are the weapon of choice to attack high-value, heavily defended targets. Combined cruise missile and tactical aircraft attacks now dominate the conduct of air warfare.

—*Gilles Van Nederveen*

See also: Ground-Launched Cruise Missiles; Missile Defense; Sea-Launched Cruise Missiles

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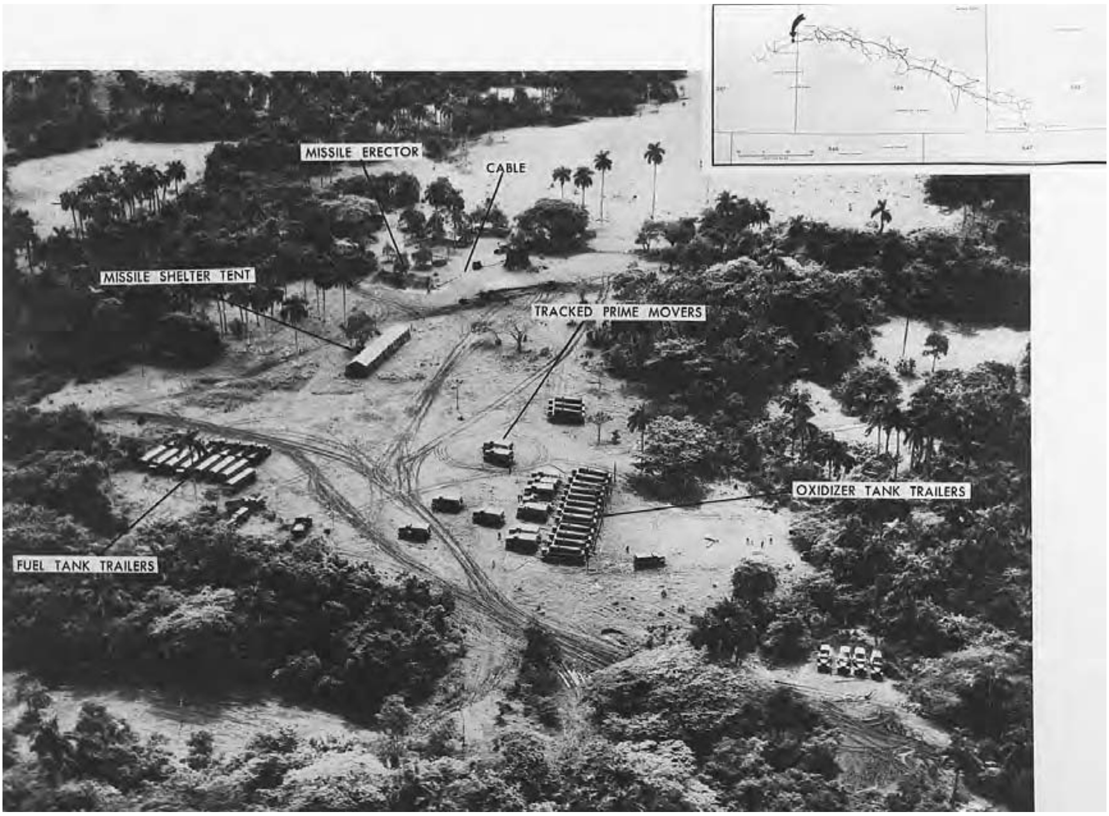
CUBAN MISSILE CRISIS

The Cuban missile crisis was a diplomatic and military standoff between the United States and the Soviet Union precipitated by the U.S. discovery of a Soviet installation of intermediate- and medium-range ballistic missiles (IRBMs and MRBMs) in Cuba on October 14, 1962. The ensuing crisis brought the two countries to the brink of nuclear confrontation, only ending when the Soviets agreed to remove their missiles and bombers from Cuba.

Fearing a U.S. invasion of Cuba (which had become Communist with the accession of Fidel Castro as president in 1959), and wishing to respond in kind to the U.S. placement of Jupiter IRBM missiles in Turkey, Soviet Secretary General Nikita Khrushchev had considered the deployment of IRBMs and MRBMs to Cuba as early as April 1962. By September 1962, parts and equipment for forty-two SS-4 MRBMs and thirty-two SS-5 IRBMs began arriving in Cuba. In addition to the missiles, the Soviets sent 42,000 troops, MiG-21 jets, IL-28 bombers, and coastal defense forces.

The Crisis

On October 14, 1962, an American U-2 reconnaissance aircraft photographed Soviet missile sites in San Cristobal, Cuba. Shortly thereafter, the



An aerial reconnaissance photograph showing a missile launch site in San Cristobal, Cuba. The discovery of such Soviet missile sites led to the Cuban Missile Crisis in October 1962. (Bettmann/Corbis)

administration of President John F. Kennedy decided that the United States could not allow the missiles to remain in Cuba. By October 21, Kennedy had decided to impose a naval blockade on Cuba. The next day, the president addressed the nation, announcing the presence of Soviet missiles in Cuba and the U.S. naval blockade of the island. Simultaneously, U.S. forces worldwide were put at Defense Condition (Defcon) 3 and U.S. nuclear forces were put at Defcon 2, only one level short of war.

On October 25, U.S. intelligence reported that at least some of the Soviet missiles were operational. At the same time, the Kennedy administration agreed to Operational Plan 316. The plan, involving a full-scale invasion of Cuba, was deemed the best option if military action became necessary to remove the missiles. It would have involved massive air strikes, an airborne assault, and an amphibious landing.

October 27 was the most pivotal day of the crisis. The day began with a message from Khrushchev suggesting that the U.S.S.R. would remove its missiles from Cuba if the United States removed its Jupiter missiles from Turkey. On that same day, however, an American U-2 was shot down over Cuba, an event that U.S. officials viewed as a deliberate act of escalation. That evening, Attorney General Robert Kennedy met with Soviet Ambassador Anatoly Dobrynin. In the meeting, the attorney general told Dobrynin that time was running out, that the United States was willing to use military force, and that the Kremlin had one day to agree to remove the missiles. He also indicated that the United States would consider removing its missiles from Turkey. The following morning, October 28, Khrushchev announced via Moscow radio that the missiles would be removed from Cuba (*see* Inadvertent Escalation).

Post-Crisis Relations

Though the immediate danger lessened significantly on October 28, there were still a number of important issues remaining between the two superpowers.

The United States also demanded that a number of Soviet IL-28 bombers be removed from Cuba, something that Khrushchev did not agree to do until November 20. On that same day, President Kennedy announced the lifting of the U.S. naval blockade of the island. However, Kennedy continued to resist Khrushchev's pressure to sign a formal noninvasion agreement regarding Cuba, citing Cuba's refusal to allow on-site inspection and verification of the Soviet missile removals. Consequently, there was never a formal, negotiated settlement to the crisis.

—*Sean Lawson*

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D

DAMAGE LIMITATION

Damage limitation is the ability to reduce, contain, preempt, intercept, or prevent harm inflicted on one's own forces or other assets by an enemy attack. Efforts to limit damage may be applied to military forces, troops, and equipment as well as to cities, industry, population, leadership, critical communication nodes, transportation systems, national infrastructure networks, or whatever else a nation values and believes is subject to outside threats. From an operational point of view, the strategies are divided into active and passive damage limitation. Air defense, antisubmarine warfare, and missile defense are examples of active damage limitation, as is preemptive attack against the enemy's offensive forces (in order to destroy them before they can inflict casualties on one's own forces). Passive forms of damage limitation include hardening the assets to be protected, proliferating their numbers (to increase the chances that more survive and to increase the costs of attacking them), making the assets mobile so they can move around to avoid being targeted, camouflaging them, burying them, or hiding them. Civil defense measures designed to protect urban populations in the event of an attack are also a prominent example of passive damage limitation (*see* Civil Defense; Preemptive Attack).

Recently, there has been a revival of interest in damage limitation as a form of deterrence as a response to new threats that may be less amenable to traditional forms of deterrence. Therefore, the United States is increasingly pursuing forms of damage limitation such as missile defenses to back up and reinforce deterrence and to provide some insurance in case traditional deterrence fails (*see* Deterrence; Missile Defense).

—*Kerry Kartchner*

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DATA EXCHANGES

Verifying compliance with arms control agreements is a function of intelligence collection and analysis of all the information available concerning a particular activity. It is accomplished by national technical means (NTM) supplemented by cooperative measures, that is, negotiated or volunteered measures requiring the cooperation of another party or parties to the agreement. One type of cooperative measure is the exchange of data. Data exchanges involve the exchange of comprehensive sets of information, frequently including the numbers and locations of treaty-limited equipment or other items, technical characteristics of specific weapons and their associated launchers, site diagrams, information regarding force structure, and the like.

From the mid-1950s until the 1987 Intermediate-Range Nuclear Forces (INF) Treaty, verification of arms control proposals and agreements relied primarily on NTM. However, the Ronald Reagan administration pressed for very extensive and intrusive bilateral provisions, including cooperative measures, in the INF Treaty. The verification regime of the INF Treaty contained the most stringent provision in any arms control agreement negotiated to that date. It included an unprecedented exchange of data on the systems limited by the treaty, including numbers, locations, and technical characteristics of all INF missiles and launchers.

There are significant synergistic effects between NTM and data exchanges. While NTM provides useful information on the nature and scope of information expected to be included in data exchanges, the exchanges themselves provide useful information for enhancing present and future

NTM capabilities. For example, information on technical characteristics, numbers, locations of treaty-limited equipment, and site diagrams provides "sanity checks" on data based on NTM and guidance for revising and upgrading the overall conclusions and capabilities of NTM.

—*Patricia McFate*

See also: National Technical Means; Telemetry; Verification

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THE DAY AFTER

The Day After was a controversial made-for-television movie aired by the American Broadcasting Corporation (ABC) in 1983. It dramatized the prelude to a nuclear strike on Kansas City, Missouri, and the after-effects felt in nearby Lawrence, Kansas, following a fictional limited nuclear exchange between the United States and the Soviet Union. The story followed characters coping with radiation sickness, the injuries and deaths of family and friends, and massive physical destruction.

The movie was the subject of criticism even prior to its airing and received much public and media interest. It was shown at a time of worsening relations between the United States and the Soviet Union in the early 1980s following the Soviet invasion of Afghanistan, tougher rhetoric between the two countries following the period of détente, an increase in planned nuclear arms procurement, and stalled arms control talks. In this atmosphere, concerns about the outbreak of nuclear war were widespread among the American public.

Critics of the film believed that the graphic scenes depicting a nuclear attack and its effects were gratuitously shocking and would breed antinuclear and pacifist sentiment among the American public. They also charged that the movie was overtly political and that it aimed to erode public support for the nuclear policies of the Ronald Reagan administration and the U.S. nuclear deterrent. Those opposing the deployment of new nuclear systems sought to use the movie to highlight the dangers of nuclear war and to advocate nuclear disarmament, hosting public gatherings to view the movie followed by discussions on nuclear policy.

—*Michael George*

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DEALERTING

Dealerting is a reduction in the day-to-day alert status of strategic nuclear forces that diminishes their readiness for launch or introduces deliberate delays into the process of preparing them for launch. Substantial dealerting of U.S. heavy bombers, tactical and theater nuclear weapons, and North Atlantic Treaty Organization (NATO) dual-capable aircraft took place under a series of 1991 presidential nuclear initiatives.

In the mid- to late 1990s, additional proposals were introduced calling for dealerting U.S. and Russian strategic nuclear forces, ostensibly as a means of making them more secure from theft, loss, unauthorized access, or accidental launch and as a way to accelerate the dismantling and disarmament process already taking place under the Strategic Arms Reduction Treaties (START I and START II). These proposals were, in part, responses to the perceived deterioration in the Russian command and control of its nuclear forces. Measures proposed included removing nuclear warheads from operationally deployed intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and bombers and storing them at a small number of centralized locations; removing or deactivating navigational equipment needed to guide strategic nuclear delivery vehicles; piling gravel on top of missile silos; reducing at-sea deployment rates of U.S. Trident submarines; and removing the launch keys or launch codes from command and control facilities and placing them in centralized containers monitored by officials from the United

States and Russia. These proposals sometimes had much in common with other, similar proposals relating to "detargeting," "decommissioning," "deactivation," "demating," and "deposturing."

Dealerting proposals were not received enthusiastically by either U.S. or Russian officials, who feared such measures would make their respective forces less secure and more vulnerable and undermine rather than promote stability and deterrence. Also, many dealerting proposals would have been difficult to verify or implement. Ultimately, proposals for dealerting strategic nuclear forces were overtaken by other, less-problematic initiatives. For example, the United States and Russia began pursuing a Joint Data Exchange Center to improve awareness of missile threats to both countries and to share early warning data. And the security of the Russian nuclear stockpile continued to be addressed in the context of aid provided to Russia through the U.S. Cooperative Threat Reduction Program.

—*Kerry Kartchner*

See also: Cooperative Threat Reduction (The Nunn-Lugar Program); Presidential Nuclear Initiatives

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DECAPITATION

"Decapitation" refers to an attack intended to destroy a country's political and military leadership to eliminate the decision-making authority necessary to authorize and execute a nuclear counterstrike. It is an extraordinarily risky strategy because it communicates the message that one side no longer believes that a negotiated settlement of the conflict is possible and that a final nuclear showdown is now preferable to other possible solutions to a crisis or ongoing conflict. It also is dangerous because an opponent's nuclear command and control infrastructure could be constructed so that it "fails deadly." Local commanders, for instance, might be preauthorized to fire their nuclear weapons in the event they lose contact with higher authorities or if national command assets are attacked with nuclear weapons. Leaders who believe they are vulnerable to decapitation attacks also might be willing to adopt launch-on-warning or launch-under-attack strategies.

Fear of decapitation strikes thus raises the risk of accidental or inadvertent nuclear war in two ways. Pre-delegation of launch authority can reduce the negative control national authorities can exercise over their nuclear forces, increasing the threat that local commanders might use nuclear weapons on their own initiative. Launch-on-warning strategies might also be activated by false indications of attack, a threat that greatly increases during crises when militaries are on high alert.

—*Andrea Gabbitas and James J. Wirtz*

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DECLARED FACILITY

The term "declared facility" is a technical term often associated with arms control and disarmament treaties. A declared facility is a site, manufacturing plant, or military base that is subject to inspection and compliance review by other parties to a treaty or by an international governing body created to verify compliance with an international agreement (*see* Verification).

Signatories of the 1993 Chemical Weapons Convention (CWC), for example, are subject to a stringent inspection regime in which they must provide a list of "declared facilities" that are, or once were, involved in the manufacture or storage of chemical weapons. A declared facility that has been identified by a state party as a former chemical weapons facility is subject to systematic verification or on-site inspection based on declared chemical weapons–related activities or functions. Under the CWC, declared and undeclared facilities are subject to challenge inspections. Other states parties may request that the site in question be visited by a team of international inspectors to verify that the host nation has abandoned its chemical arsenal. The Organization for the Prohibition of Chemical Weapons (OPCW), created by the CWC, provides an international team of professional inspectors to undertake challenge inspections.

The 1968 Nuclear Nonproliferation Treaty (NPT) also includes a method of monitoring "declared facilities" to verify that nuclear materials are not being diverted to produce weapons. The International Atomic Energy Agency (IAEA) implements an NPT Safeguards agreement by using a system of material accountancy to make sure that nuclear materials are not being removed from declared facilities (in this context, facilities involved in peaceful nuclear activity).

—*James J. Wirtz*

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DECOYS

Anything designed to draw fire away from a military target by providing alternative or additional targets is called a "decoy." Decoys are used most often to confuse defensive systems (such as missile defense, air defense, or antisubmarine warfare) during an engagement. Decoys also can be targets for offensive systems. Cardboard airplanes and rubber submarines, for example, may serve as decoys.

Decoys are expected to be less expensive and less massive than the systems they are designed to mimic. If the cost of a decoy is comparable to the weapon system, it is usually more effective to buy real weapons and overwhelm the adversary. Concepts for operation of the MX missile used decoys that were otherwise identical launch sites without missiles in them, but these were eventually judged too costly.

Decoys fool the sensors, the information processing, or the battle management logic of the enemy. They are usually divided into three categories: high-fidelity decoys (which attempt to mimic the target in several respects), low-fidelity decoys (which usually mimic one critical characteristic), and traffic decoys (which attempt to overwhelm the information processing despite low fidelity). Examples of low-fidelity decoys are flares (against infrared sensors), noise-makers (against acoustics), and metallic balloons (against radar). For countering missile defense, high-fidelity decoys are proposed to mimic the shape, infrared signature, and motion of a reentry vehicle.

Decoys work best when they can meet three criteria: (1) they work for a sufficient amount of time; (2) decoy assembly or release can be accomplished out of the adversary's view; and (3) decoy operations can minimize the viewing angles and sensor bands available to the adversary.

—*Roy Pettis*

See also: Missile Defense; Penetration Aids

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DEFENSE THREAT REDUCTION AGENCY (DTRA)

The Defense Threat Reduction Agency (DTRA) is the U.S. Department of Defense (DOD) agency tasked with stewarding the U.S. nuclear stockpile and reducing the threat posed to the United States by weapons of mass destruction (WMD).

In 1997, U.S. Secretary of Defense William Cohen announced that among other agencies and departments affected by the DOD Defense Reform Initiative, three DOD agencies—the Defense Special Weapons Agency (DSWA), the On-Site Inspection Agency (OSIA), and the Defense Technology Security Administration (DTSA)—and elements of the Cooperative Threat Reduction (CTR) and Chemical-Biological Defense programs—would be consolidated into a threat reduction and treaty compliance agency. On October 1, 1998, the ceremony establishing the Defense Threat Reduction Agency and placing its director, Dr. Jay C. Davis, at its helm was held at Washington Dulles International Airport, the site of DTRA headquarters.

DTRA's mission, while diverse, is tied to the threat posed by weapons of mass destruction, and its directorates are appropriately mission-focused. DTRA began with eight mission-support directorates (Technology Security, Cooperative Threat Reduction, On-Site Inspection, Counterproliferation, Chemical-Biological Defense, Force Protection, Nuclear Support, and Special Weapons Technology Development) and has since reduced the number of its mission directorates to six:

- The Technology Development Directorate is focused on the development of technologies that improve force-application and protection-modeling capabilities, providing enhanced weapons and sensors for defeat of WMD-related facilities and optimizing capabilities for use by U.S. forces to enhance the survivability and operability of U.S. military equities.
- The Cooperative Threat Reduction Directorate consolidates and streamlines all aspects of management and implementation of the CTR program.
- The On-Site Inspection Directorate acts as the U.S. government lead for implementing U.S. arms control inspection, escort, and monitoring activities.
- The Combat Support Directorate provides operational and analytical support to DOD and other organizations for critical nuclear and other WMD defense matters. It is mainly responsible for DOD's nuclear stockpile stewardship and technical support duties for all DOD nuclear weapons.
- The Chemical-Biological Defense Directorate acts as the central point for all DOD chem-bio defense efforts.
- The Weapons Elimination Directorate is DTRA's newest directorate. Classified until late March 2003 when a media leak exposed its existence, the Weapons Elimination Directorate is charged with finding, cataloging, and destroying weapons of mass destruction found in Iraq.

In addition to implementing arms control agreements, DTRA has been in the forefront of many controversial technological developments, including the thermobaric warhead used in Afghanistan in 2002 and Iraq in 2003 and the Biodefense Initiative, which is intended to bolster the ability to defend the U.S. homeland and infrastructure against attack from biological weapons. DTRA also coordinates with other U.S. government agencies and departments to improve WMD counterproliferation programs; lend support and technical advice to WMD planning exercises; and provide force protection assessments and improvements.

In 2002, DTRA relocated its headquarters to Fort Belvoir, Virginia. Following the end of the term of its second director, Dr. Stephen J. Younger, in February 2004, it has been placed under the guidance of Acting Director Major General Trudy H. Clark, USAF.

—Jennifer Lasecki

See also: Cooperative Threat Reduction; Department of Defense

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DENSE PACK

"Dense pack" refers to a proposal made by the Ronald Reagan administration during its first term to develop a survivable basing mode for the new MX (for Missile Experimental) intercontinental ballistic missile (ICBM). It was an alternative to the Jimmy Carter administration's proposal to deploy the MX missile on a transporter-erector-launcher so that the missile could be shuttled along a race-track system of twenty-three shelters for each missile. It was hoped that this "shell-game" would increase the survivability of the MX, but eventually the race-track system was abandoned.

The question of missile basing was a major defense issue for the Carter and Reagan administrations. Congress, in particular, wanted to ensure that the land-based ICBM force would retain a second-strike capability. A variety of earlier proposals had been rejected as too expensive or too vulnerable to Soviet countermeasures. The Dense Pack proposal, put forward by the Reagan administration in November 1982, was one alternative that appeared to increase the survivability of the U.S. ICBM force at modest cost. Dense Pack was based on the "fratricide effect." Instead of dispersing missile silos, it would group silos closely together so that if successive enemy warheads were aimed at these silos, the effects of earlier explosions would disable the ones following. As a result, a number of the silos would be more likely to survive. In order to destroy all the silos, a nuclear strike would have to "walk" across the Dense Pack field from south to north, and if detonations occurred too quickly, they would destroy additional incoming warheads, allowing some MX missiles to survive.

Dense Pack ran into political trouble because it would have abrogated the unsigned treaty resulting from the Strategic Arms Limitation Talks (SALT II), which banned the construction of new missile silos. The idea was abandoned in favor of deploying MX missiles in existing Minuteman ICBM silos, which would receive additional protection (hardening).

—*Andrew M. Dorman*

See also: Silo Basing

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DENUCLEARIZATION

See Disarmament

DEPARTMENT OF DEFENSE (DOD)

The U.S. Department of Defense (DOD) is the bureaucratic agency responsible for housing and deploying all nuclear, biological, and chemical weapons in the U.S. arsenal. Since 1972, the United States has formally renounced the use of biological weapons even in response to an attack with biological weapons. In 1997, it committed to eliminating its chemical stockpile by 2007.

History and Background

In terms of both budget and personnel, the DOD is by far the largest bureaucracy in the U.S. government.. The defense budget routinely takes up nearly half of all discretionary spending ($336 billion in fiscal year 2002 versus $382 billion for all other categories) and employs 1,370,000 active-duty, uniformed personnel; 669,000 civilians; and another 1,280,000 uniformed military reservists (all figures as of June 2003).

The department was created with a 1949 amendment to the National Security Act of 1947 that consolidated the Departments of the Army, Navy, and Air Force under the secretary of defense, removing cabinet status from the individual services. Despite this move, early secretaries of defense found that they had little power because the individual services still controlled most aspects of budgeting, planning, and coordination within the military. A 1958 amendment to the National Security Act helped change this by removing the service chiefs from the operational chain of command and having the four-star unified commanders-in-chief, or CINCs (pronounced "sinks"), report directly to the secretary of defense.

Because most long-term planning and budgeting takes place outside of the operational commands, the services continue to wield enormous power. This has been exacerbated by the designation of the chairman of the Joint Chiefs of Staff, a subordinate of the secretary of defense, as the principal military adviser to the president by the Goldwater-Nichols Department of Defense Reorganization Act of 1986. The independent power of the chairman, the continued influence of the individual services, and congressional wrangling over the distribution of the largest pool of discretionary money have all hindered secretaries of defense in their efforts to centralize the control of military planning and spending.

Organization

The DOD's nuclear and chemical weapons arsenals are under the operational control of the services and specifically the combatant commanders.

The department's role in treaty verification is administered by the Office of Arms Control Implementation and Compliance, which is under the deputy undersecretary of defense for acquisition and technology. Two DOD agencies, the Defense Threat Reduction Agency (DTRA) and the Missile Defense Agency (MDA), also have significant roles in helping to equip and manage U.S. offensive and defensive strategic programs (*see* Defense Threat Reduction Agency [DTRA]).

The forerunner of DTRA was founded in 1991 as an outgrowth of the Intermediate-Range Nuclear Forces (INF) Treaty and the Strategic Arms Reduction Treaties (START I and START II) with the Soviet Union. Since 1993, it has been the principal DOD coordinating agency for countering the WMD threat, focusing on four functions: combat support, technology development, threat control, and threat reduction. The director of DTRA reports to the undersecretary of defense for acquisition, technology, and logistics. The director receives information from an adviser for science and technology and from senior officials from the Department of State, the Department of Energy, and the Federal Bureau of Investigation, as well as from a Threat Reduction Advisory Committee composed of distin-

The Pentagon in Arlington, Virginia, houses the Department of Defense. (Library of Congress)

guished policy, scientific, and defense experts. DTRA also has an Advanced Systems and Concepts Office charged with analyzing emerging weapons of mass destruction threats and the future technologies and concepts needed to counter them.

The predecessor of the Missile Defense Agency was created in 1984 as part of the Strategic Defense Initiative. Its role has evolved, but the agency is still responsible for developing and fielding a ballistic missile defense system, including research, development, testing, and evaluation (*see* Strategic Defense Initiative [SDI]).

As of April 2003, the United States had 10,729 intact nuclear warheads, with 274 awaiting dismantlement under the 2002 Treaty of Moscow. Of these, approximately 7,000 are strategic and 1,700 tactical. Pursuant to START II, the United States has pledged to have only 3,500 warheads active, with 500 of these on intercontinental ballistic missiles; approximately 1,650 on submarine-launched ballistic missiles; and approximately 1,350 deployed via bombers. Another 6,500 warheads, however, are authorized to be placed in an "inactive reserve," with verification protocols in place (*see* Hedge).

On April 24, 1997, the U.S. Senate ratified the Chemical Weapons Convention, which entered into force five days later. This treaty commits signatories to destroy all existing chemical weapon stockpiles, production, and other related facilities within ten years of the convention's entry into force. DOD's role in implementing this requirement is divided among several agencies. The DOD Compliance Review Group will be responsible for coordination, and the army for destruction of stockpiles, closure of storage facilities, and preparation of facilities for inspection. The navy and air force, which lack organic chemical arsenals, are responsible for preparedness for challenge inspections that could occur.

—James Joyner

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DEPARTMENT OF ENERGY (DOE)

The U.S. Department of Energy (DOE) is a cabinet-level department that focuses federal efforts and funding on energy and national security issues. The mission of DOE is to advance energy security, to promote energy advances through research and development, and to ensure that the environment remains free from nuclear weapons facility pollution. The department's overarching goal is one of national security, and it is responsible for the Stockpile Stewardship Program that maintains the long-term viability of the U.S. nuclear weapons stockpile.

The lineage of DOE started in the aftermath of World War II. The Atomic Energy Act of 1946 established the Atomic Energy Commission, a government agency responsible for U.S. nuclear weapons and the military reactor program. The civilian government had control of nuclear energy until the Atomic Energy Act of 1954 gave impetus to the commercial nuclear power industry.

The Energy Reorganization Act of 1974 established the Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC). The ERDA was given the responsibility of developing and producing nuclear weapons and promoting nuclear energy. The NRC is responsible for regulating nuclear facilities in the United States (*see* Nuclear Regulatory Commission [NRC]).

In the mid-1970s, when the United States was faced with an energy crisis produced by high oil prices, President Jimmy Carter created the Department of Energy through the Department of Energy Organization Act of 1977. On October 1 of that year, the Department of Energy was established and given the responsibility of promoting programs in energy, environmental integrity, national security, energy conservation, and general science. DOE assumed the responsibilities of the ERDA, the Federal Energy Administration, and other federal energy-related programs and agencies.

Since the early 1990s and the moratorium on testing nuclear weapons, DOE has focused on national security, nuclear weapons stockpile stewardship, conservation of energy initiatives, and environmental cleanup of nuclear weapons facilities. The department employs approximately 16,000 federal workers and 100,000 contractors. It has twenty-six laboratories, four power marketing-administration offices, and twenty-four other facilities. The annual budget for DOE is approximately $22 billion.

DOE funds a plethora of research initiatives. To surmount technical and scientific concerns over the use of nuclear energy, it has established the Nuclear Energy Research Initiative (NERI), which focuses on next-generation (Generation IV) nuclear energy technology.

As part of the NERI program, DOE has sought international collaboration with the International Nuclear Energy Research Initiative (I-NERI) to research and develop nuclear energy technology to be used worldwide. One design funded by the NERI program is the International Reactor Innovative and Secure (IRIS), a collaborative effort between the United States, the United Kingdom, Italy, Spain, Brazil, Russia, Mexico, Japan, and Croatia.

Current Stockpile Stewardship programs include Advanced Simulation and Computing, which is intended to advance computational modeling, and the National Ignition facility, which provides a new basic research tool for nuclear physics. The Department of Energy, in partnership with the auto industry, is developing hydrogen fuel cells and hydrogen delivery systems to power automobiles. The Office of Science is examining new energy sources and is focused on advanced technologies to combat the terrorist threat.

—Don Gillich

See also: Nuclear Emergency Search Teams; Stockpile Stewardship Program

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DEPARTMENT OF HOMELAND SECURITY (DHS)

In the aftermath of the September 11, 2001, terrorist attacks on the Pentagon and the World Trade

Center, President George W. Bush and the U.S. Congress formed a commission (Public Law 107-306, November 27, 2002) to investigate why the government and military were caught by surprise and to study the way existing local, state, and federal organizations responded to the attack. One of the findings of the National Commission on Terrorist Attacks upon the United States was that U.S. intelligence and law enforcement activities were divided literally at the water's edge. Coordination and cooperation between foreign intelligence, military, police, and civil defense entities and a variety of federal agencies were at best ad hoc and at worst nonexistent.

Unwilling to wait until the public debate and congressional fact finding had ended, the Bush administration requested that Congress take immediate steps to bolster the ability of a myriad of federal, state, and local agencies to defend the U.S. homeland from terrorist attack. The administration suggested that the country would be better served if a single organization was responsible for domestic border and transportation security; emergency preparedness and response; chemical, biological, radiological, and nuclear countermeasures; and information analysis and infrastructure protection. This organizational scheme is reflected in the Department of Homeland Security (DHS), which was created by the Homeland Security Act of 2002.

DHS is intended to unify the vast national network of organizations, agencies, and institutions involved in efforts to secure the nation. DHS created a strategic plan to guide the 180,000 employees who work at the various agencies that are included in the department. DHS now includes several government agencies that once existed as independent agencies; for example, the U.S. Coast Guard, the Immigration and Naturalization Service (INS), and the U.S. Customs Service. It also works with the Department of Defense and U.S. Northern Command to pool all available resources to defend North America. The ultimate goal of DHS is to prevent terrorist attacks within the United States, reduce domestic vulnerability to terrorism, and minimize the damage and speed recovery if all efforts to prevent terrorism fail.

—Jeffrey A. Larsen and James J. Wirtz

See also: U.S. Northern Command

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DEPLETED URANIUM (U-238)

Depleted Uranium (DU), or U-238, is a very hard, dense substance that is slightly radioactive. It is a byproduct of the production of enriched fuel for nuclear reactors and weapons. In this process, many of the U-235 isotopes that are normally present in uranium are removed—thus "depleting" it—leaving behind a preponderance of U-238 isotopes (*see* Actinides; Highly Enriched Uranium [HEU]; Mixed Oxide Fuel; Uranium).

In the process of manufacturing fuel for most nuclear reactors or the pits for nuclear weapons, the isotopic content of the uranium must be enriched in U-235 in order for these systems to function. At the end of the enrichment process, there are two products. One is the uranium enriched in U-235, ready for its intended nuclear applications. The other, referred to as "tails," is also known as depleted uranium.

Depleted uranium was originally viewed as simply a waste product from the enrichment process, but in the 1970s uses for depleted uranium began to emerge. The primary use of depleted uranium is in armor and penetrating weapons for U.S. tanks. Recently this application has generated considerable controversy owing to popular speculation that depleted uranium is responsible for illnesses in people exposed to the residue. Although depleted uranium is considered chemically toxic, it is not considered a radiation hazard. Depleted uranium is about 40 percent less radioactive than natural uranium.

Depleted uranium's density makes it ideal for use in tank armor and antiarmor projectiles because its mass- to-size ratio means it carries great penetrating power. Depleted uranium is extremely dense, with a density of approximately 19.1 g/cm^3 (1.7 times the density of lead). On impact, depleted uranium shears normal to the impact surface, creating a self-sharpening effect that greatly aids its penetration. This combination of high density and shearing makes it an ideal material to use in making antiarmor ammunition that uses kinetic energy as its primary mechanism of destruction. It appears mostly in tank shells and in the 30 mm rounds fired by the

U.S. A-10 ground-attack aircraft. DU munitions have been employed in recent wars in Iraq and Kosovo.

After passing through a target, DU rounds tend to burn up, creating tiny airborne particles of U-238. These particles can be inhaled and ingested and are not only chemically toxic but, since they can lodge in the body for many years and emit small quantities of both alpha and gamma radiation, can be radiologically toxic as well. U-238 dust has been suggested as one source of "Gulf War Syndrome," a series of mysterious illnesses that afflicted U.S. veterans of the first Gulf War. There is some debate, however, over the actual danger that DU represents. The U.S. military denies that it is especially hazardous and continues to use DU because it is an inexpensive and highly effective weapon. In fact, the Department of Energy, which maintains a stockpile of some 320,000 metric tons of depleted uranium, gives DU away free to U.S. arms manufacturers. Alternatives, such as tungsten, are expensive and not as effective.

In addition to its use as an antitank weapon and tank armor, depleted uranium is used in numerous commercial applications requiring a very dense material. Products using it include stabilizers in planes and boats, counterweights, radiation shielding, and breeding blankets in fast breeder reactors for the creation of plutonium.

Another application of depleted uranium is in nuclear weapons. It is used as a tamping device in nuclear weapons because of its high density and neutron-scattering properties. When used in this manner the depleted uranium's inertia holds the weapon together longer, allowing it to more thoroughly fission its fuel, thus increasing the yield of the weapon. Also, depleted uranium can undergo fission by fast neutrons. As a result, depleted uranium can be added to the exterior of a thermonuclear weapon to enhance its total yield. Such a weapon is referred to as a fission-fusion-fission weapon. This process greatly increases both the amount of yield and the fallout from the weapon. The largest nuclear weapons ever built or tested are of this type.

—Rod Thornton and C. Ross Schmidtlein

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DEPLOYMENT

"Deployment," or the associated term, "deployment doctrine," can have three meanings when used to describe chemical, biological, or nuclear weapons: (1) the movement of military units and equipment to combat positions, perhaps overseas; (2) the distribution of chemical, biological, or nuclear munitions to military units; or (3) the final stage in the weapons acquisition process, after production, in which delivery systems and the weapons themselves are turned over to military units.

Deployment decisions thus signal the readiness of a state or a nonstate actor to use chemical, biological, or nuclear weapons. Deploying nuclear weapons to operational units on a day-to-day basis would thus generate a willingness to use nuclear weapons quickly on the battlefield. Deploying forces in a "dealerted" status, for instance separating warheads from delivery systems that are not deployed with operational units, would demonstrate that war plans are unlikely to call for the immediate use of chemical, biological, or nuclear weapons in the event of war. A decision to deploy an unconventional weapon also provides conclusive evidence that a state or nonstate actor has weaponized an experimental "device" and is ready to incorporate nuclear, chemical, or biological weapons into its war plans and operational forces.

Deployment decisions also are important because they can greatly influence the survivability of military units, a key measure of deterrence effectiveness. Traditional ways of deploying weapons to increase their survivability include making them mobile (rail-mobile or land-mobile missiles), placing them in structures hardened to resist blast effects (missile silos), hiding them (submarine-launched ballistic missiles, airborne alert for bombers), or relying on speed to escape attack (maintaining bombers on ground alert). Deployment decisions that seek to increase the survivability of forces tend to be taken as evidence that a state has adopted a deterrence policy. Countries that intend to use nuclear, chemical, or biological weapons first in a crisis probably would not be willing to spend resources on creating a secure second-strike capability.

—Roy Pettis and James J. Wirtz

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DEPRESSED TRAJECTORY

Ballistic missiles fly in an elliptically shaped trajectory. They are launched vertically, then orient themselves in the direction of the target while their rocket engines are still burning (the boost phase). To maximize range, they are launched on a minimum-energy trajectory, which involves a missile apogee (the highest point of flight) of about 20 percent of the distance the missile travels down range. To fly below missile defense systems or to reduce the warning time provided by ground-based radars, missiles can be launched along a "depressed trajectory." In such cases, the apogee is achieved at low altitudes, causing warheads to streak toward their targets at relatively flat reentry angels and relatively high reentry speeds.

Depressed trajectory missile shots can complicate the task faced by missile defense; they also reduce the time of flight needed to strike targets that are well within the maximum range of the missile. During the Cold War, it was feared that Soviet ballistic missile submarines lurking off the United States could strike coastal cities in as little as five minutes after launch, and targets further inland in as little as fifteen. A demonstrated ability to fly ballistic missiles along a depressed trajectory would be considered highly threatening because this capability could be used to strike an opponent's urban areas or military forces with virtually no warning. Because they provide the capability to strike opponents within minutes, depressed-trajectory capabilities are likely to produce crisis instability.

—James J. Wirtz

See also: Ballistic Missiles; Missile Defense

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DÉTENTE

"Détente" means a lessening of tensions and improvement of relations between antagonistic states. Although President John F. Kennedy used the term as early as 1963 to describe a relaxation of tensions between the United States and the Soviet Union, it has become synonymous with the Richard M. Nixon administration's approach to international affairs. The Nixon administration's philosophy of détente was based on an acceptance of the realities of the international system and was an attempt to manage the interests of the two superpowers in a manner unconstrained by ideology. The Nixon administration believed that U.S. foreign policy toward a particular country should be based upon U.S. national interests and that country's conduct within the international system. Although such an approach may currently sound unremarkable, at the time it represented a significant philosophical reorientation of U.S. foreign policy. Although many legitimate criticisms of détente have been raised, the Nixon administration's adherence to the principle of détente led to the end of U.S. involvement in the Vietnam War; the establishment of formal relations with China; and the conclusion of two significant strategic arms control agreements with the U.S.S.R. during an uncertain period of the Cold War.

Given the economic strain that the Soviet strategic arms buildup had placed on its economy, Soviet leaders were anxious to reach an agreement on strategic arms limitations with the Nixon administration. On the day that President Nixon was inaugurated, the Soviet Foreign Ministry issued a formal announcement of Soviet willingness to enter into discussions with the United States concerning strategic arms limits. Eleven months later, on November 17, 1969, the first round of the Strategic Arms Limitation Talks (SALT) began in Helsinki. Over the course of the next two years, representatives from the United States and the U.S.S.R. met regularly to hammer out the terms of the agreement. The issue of compliance verification became a particularly contentious problem for both sides to agree upon. Despite such difficulties, on May 26, 1972, the first round of SALT ended with the signing of the Anti-Ballistic Missile (ABM) Treaty and the Interim Agreement on Strategic Offensive Arms at a formal ceremony in Moscow. This marked the beginning of a twenty-year period of improving relations that eventually led to the end of the Cold War.

—William S. Clark

See also: Anti-Ballistic Missile (ABM) Treaty; Arms Control; Cold War; Disarmament; Strategic Arms Limitation Talks (SALT I and SALT II); Verification

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DETERRENCE

Deterrence is the act of dissuading another state or party from undertaking a politically or militarily undesirable action, such as an arms race or an attack, that it might otherwise carry out, and can be achieved in any of three ways: by implicitly or explicitly threatening to retaliate if the undesirable action is undertaken; by providing a defense to deny an attacker's objectives; or by offering a reward for not carrying out the undesired action.

Popular notions of deterrence revolve mainly around deterrence by threat of retaliation and often ignore or discount the other two means of deterring, primarily because the threat of an overwhelming offensive nuclear retaliation became the principal, if not the exclusive, means by which the United States underwrote its policy of deterrence during the Cold War. Deterrence by threat of retaliation seeks to convince a potential adversary that the benefits of his actions will be outweighed by the costs incurred in the course of a retaliatory strike. Deterrence by denial seeks to dissuade a potential adversary by convincing him that he will not be able to achieve his objectives and is a function of some combination of passive and active defenses. Examples include civil defense, air defense, antisubmarine warfare, and missile defense. Deterrence by reward relies on inducing a potential adversary not to undertake an action by offering him a greater benefit for restraining his behavior. The policy of détente, or seeking to integrate the Soviet Union more fully into world politics through trade and security enticements, can properly be considered a reward form of deterrence.

Deterrence is at times confused with the notion of compellence. Compellence differs from deterrence in that it involves forcing or coercing another person or state to do something they would not otherwise do, rather than persuading or dissuading them not to do something they would otherwise be inclined to do (*see* Compellence).

With the dawning of the nuclear age, deterrence assumed the status of a preeminent national security objective and strategy, supplanting traditional military objectives such as seizing and holding territory or militarily defeating the enemy. As military historian and strategic analyst Bernard Brodie noted in a seminal collection of essays published in 1946, "Thus far the chief purpose of our military establishment has been to win wars. From now on its chief military purpose must be to avert them. It can have almost no other useful purpose" (Brodie, p. 76). With the advent of large nuclear arsenals in the service of competing Cold War ideologies, deterrence became the centerpiece of U.S. national security strategy and foreign policy as well as the principal objective of strategic arms control.

How Deterrence Works

Each of the three approaches to deterrence relies heavily on a rational decision-making process of evaluating costs versus benefits. Each assumes that the potential opponent will rationally choose not to undertake the forbidden action in exchange for avoiding the retaliation or the costs of surmounting a defense or accepting the proffered reward. But for this rational choice to be made, several conditions must obtain.

The deterrent threat (or reward) must be understood. Deterrence is fundamentally a process of communication. The nation making the deterrent threat must know what actions it wants to deter, who it wants to deter from undertaking those actions, and how to communicate that threat. The target of the deterrence strategy, or the "deterree," must recognize the deterrent threat and understand the costs and consequences of failing to be deterred. Obviously, lack of clear communication channels, differences in the interpretation of deterrent threats, misperceptions, miscommunications, and misunderstandings can all undermine an effective deterrence policy.

The deterrent threat must also be credible (*see* Credibility). The credibility of a deterrent threat is a function of the deterring state's collective political will to carry out the deterrent threat (or provide the promised reward) and its perceived ability or capability to carry it out (or provide the reward). If a state threatens to retaliate with means that are not at its disposal, or to carry out retaliatory threats that it may itself not believe to be credible, the chances of deterrence failure will be increased.

The issue of credibility has posed a dilemma in two key respects for U.S. nuclear weapons policy. The first dilemma is the so-called "usability" paradox. On the one hand, there are pressures to refrain from nuclear weapons development and testing (*see* Comprehensive Test Ban Treaty [CTBT], for example), which will inevitably lead to the eventual obsolescence and degradation of a nation's nuclear weapons, thus undermining their deterrent value. On the other hand, many believe that efforts to make nuclear weapons more "usable" (by developing earth-penetrating warheads or enhanced radiation warheads, for example) undercut U.S. efforts to convince other countries not to develop their own nuclear weapons by promulgating the perceived political utility of having a nuclear arsenal, thus undermining U.S. nonproliferation objectives. Others believe such development efforts are essential to enhance and strengthen deterrence.

The second dilemma involves making threats that one is unable or unwilling to carry out. Many analysts believed, at least early on in the nuclear age, that the horror of nuclear war would reduce the likelihood of war. By contrast, it is difficult to reconcile the certain consequences of all-out nuclear war with any of the key principles of just war doctrine, meaning that the United States seems at times to have placed itself in a position, for the sake of deterrence, of threatening to do that which it is morally prohibited from doing (the mass slaughter of noncombatants). Any prospective opponent, then, has to consider whether the United States could overcome its own moral inhibitions to actually carry out a deterrent threat.

Deterrence Today

Deterrence is no less important in the post–Cold War era (sometimes referred to as the "second nuclear age") than it was during the Cold War, and it remains a key pillar of national security. It is generally recognized that the implementation of an effective deterrent strategy is now immensely more complicated because the number of players (including so-called "rogue states") who have to be taken into consideration has increased. Many of these players are less well understood than enemies of past eras, and their concepts of rationality may not correspond with our own.

New threat assessments have given rise to concerns about the adequacy of traditional approaches to deterrence. U.S. officials have publicly expressed reservations about whether the traditional sole reliance on purely offensive retaliatory threats would be sufficient in all cases to dissuade leaders of rogue states from attacking the United States or its forces and allies overseas. Among the reasons for these reservations are the following:

- Leaders of rogue states may feel less constrained in their use of force, and may be more prone to take risks, than were America's adversaries during the Cold War.
- The foundation of past deterrent success—vested interest in preserving a stable environment for economic development, a mutually understood diplomatic vocabulary, and established communication channels—may not exist or may be difficult to establish.
- The United States and its allies may not understand the fundamental political and military values within potential aggressor governments well enough to implement deterrence by offensive threats alone.
- There may be significant asymmetries in the stakes involved in a regional crisis that could work to undermine deterrence. For example, some potential adversaries may believe that while their own survival is at stake in a regional conflict, the survival of the United States is not. As a consequence, these adversaries may calculate that the United States, possibly acting with its allies, with less to lose, may decline to intervene, or may back down if the stakes are escalated.
- Leaders of rogue states may believe that they have more to lose from *not acting* than from taking a particular course of action. Failure to act may cause a leader to lose face within his ruling party or power base.
- Potential adversaries may hope that the acquisition of WMD and their delivery systems, such as long-range ballistic

> missiles, would deter the United States from intervening in, or leading coalitions against, their efforts at regional aggression, or these states may believe that such capabilities would give them the ability to threaten allied countries in order to dissuade them from joining such coalitions.

Some believe that the leaders of such states may see nuclear, biological, and chemical weapons and ballistic missile capabilities as tools of coercion, terror, blackmail, and aggression. Nuclear weapons and other weapons of mass destruction, as well as ballistic missiles, also may be regarded as symbols of power and prestige by rogue states. These weapons may even be considered weapons of choice, rather than weapons of last resort. Thus, nuclear weapons use may not have the same stigma associated with it as among established nuclear powers.

Some American and European commentators claim that America's overwhelming military supremacy alone constitutes an adequate deterrence against any attack by a rogue state. But in a study of deterrence failures throughout history, RAND analyst Barry Wolf identified three types of circumstances under which weaker states actually attacked stronger states, that is, instances where deterrence failed: (1) The weaker state was highly motivated by a strong commitment to particular values, by an agenda set by a psychopathological leader, or by a cost-benefit calculus that differed from the international norm or expectation and was thus "irrational" by definition; (2) the weaker state misperceived some aspect of the situation—for example, the weaker state perceived a vulnerability that did not exist, expected no retaliation from the strong state, or believed that allies would come to its aid; (3) the stronger state was vulnerable in some respect, and the weaker state exploited this asymmetry.

Some contemporary threats may be "undeterrable" by their very nature. This includes the accidental or unauthorized launch of a long-range ballistic missile—an eventuality many believe is increasingly likely. The threat of offensive retaliation would have little bearing on preventing such incidents, thus falling outside the range of threats addressed by deterrence alone.

Today, the concept of deterrence is being expanded to include efforts to deter nonstate actors as well, and this has further complicated the formulation of effective deterrence strategies. The increasing prevalence and lethality of terrorism has spurred efforts to further explore the psychology of terrorist groups and leaders with the objective of establishing more effective deterrence policies. Some observers believe that given their bloodlust and commitment to using violence to achieve their objectives, terrorists are ultimately undeterrable and have to be stopped from carrying out their nefarious schemes.

In some respects, however, there is nothing new about focusing on individuals as the ultimate target of deterrence strategies. Scholars have long recognized that a state of deterrence exists only in the minds of the leaders of the states on both sides of the deterrence equation. In the immediate aftermath of the Cold War, some scholars briefly entertained the idea that certain rogue leaders may be literally "undeterrable," and while history suggests that there were cases where leaders were motivated by decidedly irrational factors (for example, Adolf Hitler's determination to respond to "voices" in his mind) that virtually placed them beyond the effects of any deterrent strategy, for the most part, all leaders are in some way "rational" and responsive to certain threats and enticements. Analysts increasingly recognize that what one leader considers "rational," however, may differ considerably from what other leaders would consider "rational." This recognition has, in turn, spawned increasing academic efforts to explore cultural differences in decision-making and political and military motivation.

Criticism of Deterrence

Deterrence as a theory, a strategy, and a policy has been the subject of considerable criticism in academic studies of decision-making and defense policy. Much of this criticism is focused on retaliatory deterrence, however, rather than on deterrence that takes the form of denial or rewards. Critics focus on several points:

- Deterrence relies too heavily on assumptions of rationality, on the assumption that the prospective opponent is a rational, unitary decision-maker.
- Effective deterrence assumes perfect, unimpeded communications, both in terms of the sender of the deterrence threat knowing what his objectives are, and the

receiver understanding the deterrence threat and its implications, which are difficult conditions to achieve in practice.

- It is difficult, if not impossible, to design deterrence strategies that correspond to all options open to a potential adversary.
- Since deterrence is defined as ensuring that an opponent does not do something he might otherwise do, it is difficult to prove that any given deterrence strategy has been successful.
- Alternatively, deterrence strategies can fail incrementally, and governments historically have had difficulty recognizing when a deterrent strategy is in the process of failing until it is too late to deter a direct attack.
- Deterrence has been interpreted as primarily a function of military force, with a lack of attention to the political, cultural, and perceptual aspects of communicating threats to potential adversaries.
- Deterrence is most necessary in crisis situations, but it is precisely under intense crisis situations that rationality breaks down, communication becomes difficult, and perceptions become distorted (*see* Crisis Stability).

Recent policy initiatives by the U.S. government have sought to restore balance and diversity to the notion of deterrence, long thought of exclusively in terms of offensive retaliation. These initiatives acknowledge the potential contributions of damage limitation and active defenses to deterrence. In any case, deterrence remains a central objective of national and international security and stability.

—*Kerry Kartchner*

See also: Cold War; Damage Limitation; Extended Deterrence; Firebreaks; Game Theory; Minimum Deterrence; Superiority

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DEUTERIUM

Deuterium, also known as heavy hydrogen, is the name given to one of two stable isotopes of the element hydrogen. Deuterium makes up 0.015 percent of all hydrogen. Deuterium's additional mass results from its nucleus containing a neutron in addition to the single proton held by normal hydrogen. Deuterium has nuclear properties that are very useful in both fission and fusion reactions. It is used extensively in the commercial nuclear industry, where it is combined with oxygen to form heavy water (D_2O) (*see* Heavy Water). In thermonuclear weapons, deuterium is used in both the primary and secondary stages of the weapon.

Speculation on the existence of a heavy isotope of hydrogen was first made in 1919 by O. Stern and M. Volmer in Germany. This speculation attempted to explain hydrogen's departure from an atomic weight of 1. In 1920, both W. D. Harkins and E. Rutherford began to suspect that a new particle, the neutron, might exist that would help account for hydrogen's anomalous mass. In 1931, H. C. Urey, F. G. Brickwedde, and G. M. Murphy of the U.S. National Bureau of Standards conducted a thorough search for a heavy hydrogen isotope through an evaporation experiment. In this experiment, a large mass of liquid hydrogen was evaporated to concentrate the heavy hydrogen in the remaining liquid. Subsequent analysis of the optical spectra showed spectral lines that indicated an isotope with a mass very near two, indicating the presence of heavy hydrogen. The discoverers named this heavy isotope deuterium from the Greek word *deuteros* (second) (*see* Isotopes).

Deuterium is useful in both fission and fusion reactions (*see* Fission Weapons; Fusion). In fission reactions, deuterium, in heavy water, is used to moderate (slow) neutrons for enhanced absorption of the neutrons in the fuel. This occurs because of deuterium's large scattering-to-absorption cross-section ratio. In fusion reactions, deuterium and tritium collisions have the highest probability of undergoing fusion at the temperatures that exist in most fusion systems and are thus the reaction of choice for most fusion applications (*see* Tritium). This is true for both commercial and military applications of fusion reactions. In a nuclear weapon, deuterium is used in two systems within the weapon. In a nuclear weapon's primary stage, a small quantity of deuterium and tritium gas is used to boost the yield through these fusion reactions. In the second stage of a thermonuclear weapon, deuterium with lithium in the form lithium-deuteride (LiD) is used to produce a compact fusion energy source, adding greatly to the weapon's total yield (*see* Thermonuclear Bomb).

Deuterium will remain important for both fission and fusion nuclear systems. In particular, it is used in Canada's Deuterium Uranium (CANDU) and Advanced CANDU reactors (*see* Canada Deuterium Uranium [CANDU] Reactor). Both magnetic and inertial confinement fusion systems will continue to extensively use deuterium as a fuel. Additionally, deuterium will remain a primary component in the primary and secondary stage of thermonuclear weapons.

—*C. Ross Schmidtlein*

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DIRTY BOMB

See Radiological Dispersal Device

DISARMAMENT

Disarmament refers to the reduction or abolition of a nation's military forces and armaments. Although it is often thought of as a process resulting from mutual agreement, historically it has most often been something imposed on the vanquished by the victors. For example, the ancient Romans imposed disarmament restrictions on their rivals and on those lands conquered by the Roman legions. Napoleon dictated limits on the military strength of Prussia and Austria after defeating them. The Rush-Bagot Agreement of 1817, which followed the War of 1812, demilitarized the Great Lakes between the United States and Canada.

The term "disarmament" is often used interchangeably with "arms control," but the two terms should be considered distinct concepts. "Arms control" can refer to an agreed reduction in the level of a nation's armaments, to a mutual freeze in producing new weapons, or even to a controlled increase in certain areas of weapons, whereas "disarmament" refers strictly to a reduction or abolition of arms. "Disarmament" has been a recognized entry in the lexicon on international politics and diplomacy throughout history, but "arms control" per se is a relatively recent conceptual and diplomatic development, specifically elaborated as a more modest and practical alternative to the longstanding post–World War II impasse on disarmament proposals.

Contemporary notions of disarmament by mutual agreement have their origins in the nineteenth century, when it was believed that major wars were the result of arms competitions among the major powers. If the unchecked buildup of arms were a primary cause of war, it was reasoned, then negotiated controls on this process, accompanied by substantial reductions in the quantity of arms accumulated by the great powers, would reduce the tensions and mutual suspicions that resulted from unconstrained arms competition, and thus reduce the likelihood of war.

The events leading up to World War I seemed to confirm the hypothesis that unfettered arms competitions lead to war, and disarmament became a major feature of the postwar settlement. The Treaty of Versailles disarmed Germany, imposed limits on the size and composition of its army and navy, and was intended to prevent Germany from posing a military threat thereafter to the region. The Washington and London Naval Agreements were negotiated after World War I, but they were not strictly disarmament agreements. Rather, they imposed limitations on the buildup of naval battleships and the locations of naval facilities. Lengthy disarmament conferences under the auspices of the League of Nations during the 1920s and 1930s failed to achieve any effective disarmament or to stop the onset of World War II. After World War II, both Germany and Japan were once again disarmed. More than fifty years later, both nations still observe important limitations on their military forces and how those forces may be used.

Disarmament negotiations again dominated the post–World War II agenda, with a new focus on nuclear weapons rather than battleships. From 1946 through 1948, diplomats argued the merits of competing U.S. and Soviet plans for international control of atomic weapons, but American insistence on the internationalization of atomic energy (a stance it later dropped), and Soviet reluctance to accept intrusive verification, led to a prolonged stalemate in these negotiations. Plans for "general and complete disarmament" were repeatedly proposed in the United Nations but yielded no results. It was not until after the shock of the first testing of a Soviet intercontinental ballistic missile and the orbiting of Sputnik in the fall of 1957 that the superpowers began taking the need for nuclear disarmament seriously. A series of conferences was convened beginning in 1958 to discuss ways to reduce mutual fears of a nuclear surprise attack. These led in turn to small incremental steps, such as the 1958 moratorium on nuclear testing, the 1959 agreement to demilitarize the Antarctic, and measures to demilitarize outer space and establish a "Hot Line" communication link between the superpowers. The development of surveillance satellites would eventually usher in an era of increasingly ambitious arms control agreements, but anything resembling actual disarmament would have to await the winding down of the Cold War that began in the 1980s. The Intermediate-Range Nuclear Forces (INF) Treaty of 1987 and the Strategic Arms Reduction Treaties (START I and II) of 1991 and 1993 must be considered the first superpower agreements to actually call for partial nuclear disarmament (*see* Cold War; Intermediate-Range Nuclear Forces [INF] Treaty; Moratorium; Strategic Arms Reduction Treaty [START I]; Strategic Arms Reduction Treaty [START II]).

Article VI of the 1968 Nuclear Nonproliferation Treaty, one of the most important modern international arms control agreements, contains an obligation "to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control." But it does not impose a timeline for achieving these objectives. These obligations are assumed by all parties to the NPT (*see* Nuclear Nonproliferation Treaty [NPT]). Nevertheless, the United States and the other nuclear weapon states are frequently called on to justify their compliance with the nuclear disarmament obligations. U.S. officials note, in reply, the series of strategic arms limitation agreements signed with the Soviet Union and its successor states, which have led to a substantial reduction in medium- and intermediate-range nuclear forces (such as the 1987 INF Treaty) and in strategic nuclear weapons (START I and the 2002 Moscow Treaty), as well as those unilateral disarmament measures and initiatives undertaken shortly after the end of the Cold War.

Denuclearization, or the complete elimination of nuclear weapons, is a form of disarmament advocated by contemporary peace groups. Applied universally, this has proven to be a utopian aspiration. However, agreements have been concluded regarding the denuclearization of specific geographic regions, such as the Antarctic, outer space, Latin America, and the seabed (*see* Nuclear Weapons Free Zones [NWFZs]).

The prolonged deadlock in international disarmament negotiations has led some to advocate a strategy of unilateral disarmament by undertaking one-sided initiatives. Such schemes are predicated on the assumption that fear, tension, and mistrust on both sides interfere with natural preferences to disarm, and that by demonstrating peaceful intentions through undertaking unilateral disarmament measures, one side or the other could evoke reciprocation from the other side, thus leading to a reverse arms race cycle of incremental reduction in armaments and tensions.

—*Kerry Kartchner*

See also: Arms Control; Détente; Downloading; Fissile Material Cutoff Treaty; Presidential Nuclear Initiatives; Verification

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DISTANT EARLY WARNING (DEW) LINE

Construction of the Distant Early Warning (DEW) Line began in February 1954 when President Dwight D. Eisenhower signed the bill approving construction. Located north of the Arctic Circle, the integrated chain of sixty-three radar and communications sites stretched 3,000 miles from Point Barrow on Alaska's northwest coast to the Eastern Shore of Baffin Island opposite Greenland. Construction took place between 1955 and 1957.

The DEW Line was an extension of two previous radar picket lines installed in Canada to provide warning of a Soviet transpolar airborne attack: the Mid-Canada, or McGill, Line, and the Pine Tree Line. The Pine Tree Line was sited along the U.S.-Canadian border and provided warning and control functions for the North American Aerospace Defense Command (NORAD). The Mid-Canada Line was not a radar line but a microwave fence that signaled when anything (including geese) flew through it.

The purpose of these warning networks was to prevent strategic surprise by manned Soviet bombers and allow American nuclear forces warning time to retaliate. The system thus had defense in depth and backups in case of failure. The DEW Line was upgraded in 1985 and renamed the North Warning System. It still forms part of the NORAD warning system.

—Gilles Van Nederveen

See also: Ballistic Missile Early Warning System; Early Warning; North American Aerospace Defense Command

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DOWNLOADING

Downloading of nuclear warheads is the process whereby nuclear warheads are removed from the reentry vehicle (RV) or "bus" that sits atop intercontinental ballistic missiles (ICBMs) or submarine-launched ballistic missiles (SLBMs). Downloading RVs is the preferred way to reduce the number of nuclear warheads contained in an arsenal for arms control purposes because it allows the parties involved to retain expensive delivery vehicles while reducing the overall number of deployed nuclear weapons. Downloading also is reversible. If the strategic situation deteriorates, RVs can be replaced on the bus over a period of months to once again increase the overall size of a nuclear arsenal. Disarmament advocates often criticize RV downloading because it is a reversible step in the reduction of a nuclear arsenal.

If done in a reciprocal fashion, RV downloading also increases the survivability of land-based ICBMs. Because it is generally believed necessary to attack a single hardened missile silo with at least two nuclear warheads to guarantee its destruction, an opponent armed with single-warhead missiles would exhaust its nuclear arsenal in an effort to destroy a land-based missile force of equal size. It is unlikely that an opponent would launch this type of "self-disarming" attack knowing that the opponent would be left with about half of its nuclear force intact. Downloading thus increases crisis stability by decreasing both the incentive and capability of either side in a nuclear balance to be first to use nuclear weapons in a crisis.

—James J. Wirtz

See also: Crisis Stability; Intercontinental Ballistic Missiles; Reentry Vehicles

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DUAL-TRACK DECISION

The "dual-track decision" was a policy of the North Atlantic Treaty Organization (NATO) adopted in 1979 to pursue arms control negotiations and missile deployments in Europe simultaneously.

In the mid-1970s, the Soviet Union had achieved rough strategic parity in strategic nuclear arms with the United States, and the Soviet Union turned its attention to confronting European and Asian forward-based systems. The aging Soviet intermediate-range SS-4 and SS-5 missiles at fixed bases were replaced with a new SS-20 missile. In early 1977, the Soviet Union began deployment of the SS-20 missile, a modern, mobile, nuclear-armed, intermediate-range ballistic missile with three independently targetable warheads and the range to target all of Western Europe.

West German Chancellor Helmut Schmidt feared a decoupling of the American strategic nuclear deterrent from the defense of Western Europe. In a 1975 London speech, he warned that the United States needed to counter the growing Soviet threat. These theater nuclear forces were referred to as "gray area weapons" by Schmidt and other Western leaders because they had not been included in the treaties resulting from the Strategic Arms Limitation Talks (SALT I and SALT II). Some also referred to the weapons as "Euro-Strategic" forces. During a 1979 meeting on the island of Guadeloupe, U.S. President Jimmy Carter, President Giscard d'Estaing of France, Prime Minister James Callaghan of Great Britain, and Chancellor Schmidt agreed to develop a political and military response to the SS-20 deployments. The problem for Western European leaders was that after the debacle surrounding the Carter administration's decision not to deploy the enhanced radiation warhead in Europe, they needed to show some consensus about the Western strategic policy.

In 1977, the NATO Nuclear Planning Group started a study, and in 1979 it proposed a dual-track approach to the Soviet Union regarding the SS-20 deployment that encompassed both NATO force modernization and arms control initiatives. The NATO alliance planned to deploy 464 ground-launched cruise missiles to Italy, Belgium, the Netherlands, Britain, and West Germany. It would also deploy 108 Pershing II intermediate-range ballistic missiles with earth-penetrating warheads and a longer range to replace the Pershing I in West Germany. These missiles were particularly well suited to destroying Soviet command and control bunkers. The alliance also proposed negotiations in Geneva that, if successful, would preclude the need for this proposed modernization of NATO theater nuclear force modernization. On December 12, 1979, NATO unanimously adopted the dual-track decision.

NATO had no equivalent missile to the SS-20 and the Soviet deployment was widely perceived as upsetting the balance of nuclear forces in Europe. One track of the dual-track decision called for arms control negotiations with the Soviet Union to restore the balance in intermediate-range nuclear forces (INF) at the lowest possible level. NATO's second track was to modernize its INF arsenal. Both tracks would be pursued simultaneously, with the goal of reaching an arms control treaty that would limit INF modernization or even eliminate the need for the deployment of new NATO theater nuclear forces. Deployment of these systems in Western Europe was scheduled to begin in December 1983. NATO, as a sign of good faith, also decided to withdraw 1,000 of its approximately 7,400 tactical nuclear warheads deployed in Europe and to retire an existing nuclear weapon for every new nuclear weapon deployed.

In October 1980, preliminary INF talks between the United States and the Soviet Union began in Geneva. The talks continued through November 1983. The Soviet delegation walked out of the talks following the West German Bundestag's approval of Pershing II deployments on November 22, 1983. Unable to block further NATO deployments through political pressure, and facing increasing criticism for obstructing the arms control track, the Soviet Union agreed in early 1985 to resume INF talks as a subset of the new U.S.-Soviet Nuclear and Space Talks (NST). Both the arms control and deployment tracks were brought to a close on December 8, 1987, with the signing of the Treaty on the Elimination of Intermediate-Range and Shorter-Range Missiles (INF Treaty).

—Steven Rosenkrantz and Gilles Van Nederveen

See also: Arms Control; Intermediate-Range Nuclear Forces (INF) Treaty; North Atlantic Treaty Organization (NATO)

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E

EARLY WARNING

"Early warning" refers to the prompt detection of the launch or approach of incoming reentry vehicles or bombers, thus enabling the targeted country to retaliate, take cover, or possibly shoot down the opponent's attacking forces. Early warning is usually accomplished by a network of surveillance satellites and long-range radar.

The United States maintains several surveillance satellite systems to provide early warning of attack. The Defense Support Program (DSP) uses heat-sensing devices to detect missile launches and nuclear explosions anywhere on the planet and then instantaneously relays that information to the U.S. command and control networks. The DSP satellites are placed in geosynchronous-equatorial orbit. Their infrared telescopes provide intermittent coverage of events on the Earth because the satellites rotate at about six revolutions per minute to maintain stability while in orbit. There are three primary and two backup satellites in orbit at 60°E, 70°W, and 134∞W. Because of the importance of the mission, a new satellite will normally be launched as the oldest one on-orbit nears the end of its operational life. The newly launched satellite will then assume front-line duty, the eldest of the three front-line satellites will assume backup status, and the oldest satellite will be retired.

The 1960s technology employed in DSP is becoming obsolete. In response, the U.S. Air Force is developing and deploying two different types of satellites: the Space-Based Infrared Radar System (SBIRS)-High and the SBIRS-Low. SBIRS-High satellites will replace the DSP satellites by about 2010. Because it is three-axis stabilized, the sensors on SBIRS-High can "stare" at the ground continuously rather than sweeping over a specific point every ten seconds, thereby providing a continuous data flow of events on the ground. SBIRS-Low satellites will operate in low Earth orbit and track missiles as they fly above the horizon, offering much more accurate information on their trajectories. Such information is necessary for an effective antiballistic missile defense. In 2001, the George W. Bush administration changed the name of SBIRS-High to simply SBIRS, and SBIRS-Low became the Space Tracking and Surveillance System.

—Abe Denmark

See also: Ballistic Missile Early Warning System; Distant Early Warning Line; North American Aerospace Defense Command; Phased-Array Antenna; Reconnaissance Satellites; Space-Based Infrared Radar System; Surveillance

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ELECTROMAGNETIC PULSE

See Nuclear Weapons Effects

EMERGENCY ACTION MESSAGE (EAM)

An Emergency Action Message (EAM) is a data communication from the U.S. Joint Chiefs of Staff that contains preplanned, time-sensitive instructions from high-level authorities to carry out nuclear attacks . EAMs also may contain information (coded authorization materials) needed to carry out the attack itself. They are in predetermined formats and transmitted through a variety of communication systems. Teams tasked with processing EAMs practice decoding EAMs so that they can implement their orders as quickly as possible when a real message arrives. The EAM processes, responses, and handling procedures are closely guarded secrets.

—Zach Becker

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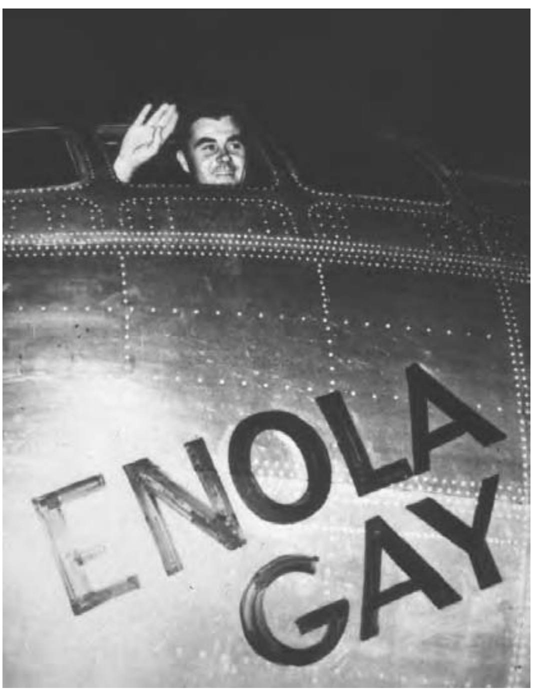
ENOLA GAY

The *Enola Gay* was the B-29 Superfortress that dropped the first atomic bomb on Japan. It was manufactured by the Boeing Aircraft Company and assembled by the Glenn L. Martin Company, Omaha, Nebraska. The *Enola Gay* was flown from the United States to the South Pacific, arriving at North Field on the Island of Tinian on July 2, 1945. The crew spent approximately one month training for the mission.



Colonel Paul W. Tibbets, Jr., pilot of the Enola Gay, *waves from his cockpit before takeoff to bomb Hiroshima, August 6, 1945. (National Archives)*

On the morning of August 6, 1945, the *Enola Gay,* commanded by Colonel Paul W. Tibbets, left Tinian for its target, the city of Hiroshima, Japan, carrying one atomic bomb named "Little Boy." The *Enola Gay* dropped its bomb on the city of Hiroshima at 8:16 A.M. Three days later, another B-29 (*Bockscar*) dropped an atomic bomb ("Fat Man") on Nagasaki, Japan. Japan surrendered on September 2, 1945.

The Smithsonian Institution's decision to place the *Enola Gay* on display in the new Air and Space Museum located near Washington's Dulles Airport in commemoration of the fiftieth anniversary of World War II stirred much controversy in the 1990s.

—Sean Lawson

See also: Fat Man; Hiroshima; Little Boy; Nagasaki

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ENRICHMENT

Enrichment is a process that turns natural uranium into a fissionable material. Naturally occurring uranium contains only 0.72 percent of U-235, the highly fissionable isotope, and the rest of the material consists of less fissionable isotopes. The fissile material must be separated from the rest of the uranium through enrichment. Uranium enriched to 20 percent or more U-235 is called "highly enriched uranium" (HEU). Uranium enriched to less than 20 percent is called "low enriched uranium" (LEU) (*see* Highly Enriched Uranium [HEU]; Low Enriched Uranium [LEU]; Uranium).

The earliest successful enrichment methods were electromagnetic isotope separation (EMIS), a process that utilizes large magnets to separate ions of the two isotopes; and gaseous diffusion, where the gas uranium hexafluoride (UF_6) is passed through a porous barrier material to separate the lighter molecules containing U-235. The first large-scale uranium-enrichment facility, the Y-12 plant at Oak Ridge, Tennessee, used EMIS in devices designated "calutrons." The process was developed by Edward Lawrence. EMIS was abandoned in the United States because of its high consumption of electricity but was adopted by the Iraqis prior to the first Gulf War.

More efficient enrichment methods were developed after World War II. Gas centrifuges, in which UF_6 gas is whirled inside a complex rotor assembly and centrifugal forces push the molecules containing the heavier isotope to the outside, are the most common. Many stages are required to produce the highly enriched uranium needed for a weapon, but the gas centrifuge enrichment technique requires substantially less electricity than either of the older technologies. Atomic or molecular laser isotope separation is still under development in the most technologically advanced countries. This process uses lasers to selectively excite atoms or molecules containing one isotope of uranium so that it can be preferentially extracted. The South African nuclear program used an aerodynamic separation technique in an indigenously designed and built device called a "vortex tube." In the vortex, a mixture of UF_6 gas and hydrogen is injected tangentially into a tube that tapers into a small exit aperture at one or both ends, and centrifugal force causes the separation. The Becker Nozzle Process, another aerodynamic separation technique, was developed in West Germany. Aerodynamic enrichment processes require large amounts of electrical power and are not currently considered economically competitive.

Yellowcake

UF_6 is used as the feedstock in the gas-centrifuge and gaseous-diffusion processes, and uranium tetrachloride (UCl_4) is used as feed in the EMIS process. Uranium ore concentrates, known as yellowcake, typically contain 60 to 80 percent uranium and up to 20 percent impurities. There are two commercial processes used to produce purified UF_6 from yellowcake: the solvent extraction/fluorination ("wet") process and the fluorination/fractionation ("dry") process. In each case, chemical reactions are used to convert the yellowcake to a metal or powder for use in the gaseous-diffusion and gas-centrifuge processes.

Manhattan Project scientists and engineers explored several uranium-enrichment technologies. Production plants employing three uranium-enrichment processes—EMIS, liquid thermal diffusion, and gaseous diffusion—were constructed at Oak Ridge, Tennessee. The term "oralloy" was used during World War II as a contraction of "Oak Ridge alloy" and denoted U-235 enriched to 93.5 percent.

Electromagnetic Isotope Separation

The EMIS process is based on the principle that a charged particle will follow a circular trajectory when passing through a uniform magnetic field. Two ions with the same kinetic energy and electrical charge, but different masses (such as U-235 and U-238), will have different trajectories, with the heavier U-238 ion having the larger diameter trajectory. This allows for the development of means to separate the two isotopes. EMIS is a batch process that can produce weapons-grade material from natural uranium in two stages.

In the EMIS program of 1945 in the United States, production of weapons-grade uranium took place in two enrichment stages, referred to as the "a" and "b" stages. The first stage used natural or slightly enriched uranium as feed and enriched it to 12 to 20 percent U-235. The second stage used the product of the first stage as feed and further enriched it to weapons-grade uranium. To allow more efficient use of magnets and floor space, the individual stages were arranged in continuous oval or rectangular arrays (called "racetracks" or simply "tracks") with separator tanks alternated with electromagnetic units. The EMIS separators are referred to as "calutrons" because the development work was carried out at the University of California at Berkeley during the early 1940s using cyclotrons.

Thermal Diffusion

Thermal diffusion utilizes the transfer of heat across a thin liquid or gas to accomplish isotope separation. By cooling a vertical film on one side and heating it on the other side, the resultant convection currents will produce an upward flow along the hot surface and a downward flow along the cold surface. Under these conditions, the lighter U-235 gas molecules will diffuse toward the hot surface and the heavier U-238 molecules will diffuse toward the cold surface. These two diffusive motions, combined with the convection currents, will cause the lighter U-235 molecules to concentrate at the top of the film and the heavier U-238 molecules to concentrate at the bottom of the film.

The thermal-diffusion process is characterized by its simplicity, low capital cost, and high heat consumption. A production plant containing 2,100 columns (each approximately 15 meters long) was operated in Oak Ridge for less than a year. Each of these columns consisted of three tubes. Cooling water was circulated between the outer and middle tubes, and the inner tube carried steam.

Gaseous Diffusion

The gaseous-diffusion process depends on the separation effect arising from the molecular flow of gas through small holes. Gas is forced through a series of porous membranes with microscopic openings. Lighter molecules are more likely to enter the barrier pores than are heavier molecules. For UF_6 the difference in velocities between molecules containing U-235 and U-238 is small (0.4 percent), and, consequently, the amount of separation achieved by a single stage of gaseous diffusion is small.

UF_6 is a solid at room temperature but becomes a gas when heated above 135 degrees Fahrenheit. The solid UF_6 is heated to form a gas, and the gaseous-diffusion enrichment process begins. Because the U-235 is lighter, it moves through the barriers more easily.

The main components of a single gaseous-diffusion stage are a large cylindrical vessel, called a diffuser or converter, that contains the barrier; a compressor to compress the gas to the pressures needed for flow through the barrier; an electric motor to drive the compressor; a heat exchanger to remove the heat of compression; and piping and valves for stage and inter-stage connections and process control. The entire system must be essentially leak free, and the compressors require special seals to prevent both out-leakage of UF_6 and in-leakage of air. The chemical corrosiveness of UF_6 requires use of metals such as nickel or aluminum for surfaces exposed to the gas (for example, piping and compressors).

Gas Centrifuge

In the gas-centrifuge uranium-enrichment process, gaseous UF_6 is fed into a cylindrical rotor that spins at high speed inside a casing. When the flowing gas is rotated, enriched gas gathers at one end and depleted gas at the other end, facilitating separation of enriched from depleted atoms.

One of the key components of a gas centrifuge enrichment plant is the power supply (frequency converter) for the gas-centrifuge machines. Enriching uranium to weapons grade typically requires several thousand stages and thus is usually done in large facilities. Large transformers are required to take commercially supplied power and convert it into higher frequencies to supply gas-centrifuge motors. This power plant signature can give away a facility's purpose and can be used by U.S. intelligence to detect nuclear activities in other nations.

Aerodynamic Processes

Aerodynamic uranium-enrichment processes include the separation-nozzle process and the vortex tube–separation process. These aerodynamic separation processes depend upon separation produced by pressure gradients, as does the gas-centrifuge method. In effect, aerodynamic processes can be considered nonrotating centrifuges. Since pure UF_6 gas cannot give these processes the velocity rate needed for separation, a carrier gas (for example, hydrogen and helium) is used.

The separation-nozzle process was developed by E. W. Becker and associates at the Karlsruhe Nuclear Research Center in Germany. In this process, a mixture of gaseous UF_6 is compressed and then directed along a curved wall at high velocity. The heavier U-238 bearing molecules move preferentially out to the wall relative to those containing U-235. At the end of the deflection, the gas jet is split by a knife edge into a light fraction and a heavy fraction, which are withdrawn separately.

The Uranium Enrichment Corporation of South Africa developed and deployed its own aerodynamic process, characterized as an "advanced vortex tube" or "stationary-walled centrifuge," at the so-called "Y" plant at Valindaba, South Africa. In this process, a mixture of UF_6 is compressed and enters a vortex tube tangentially at one end through nozzles or holes at velocities close to the speed of sound. This tangential injection of gas results in a spiral or vortex motion within the tube, and two gas streams are withdrawn at opposite ends of the vortex tube.

Owing to the very small cut of the vortex tube stages and the extremely difficult piping requirements that would be necessary based on traditional methods of piping stages together, the South Africans developed a cascade design technique called "Helikon." In essence, the Helikon technique permits twenty separation stages to be combined into one large module, and all twenty stages share a common pair of axial-flow compressors. None of these processes are currently used in commercial applications.

Atomic Vapor Laser Isotope Separation

The atomic vapor laser isotope separation (AVLIS) process is based on the fact that U-235 and U-238 atoms absorb light at different frequencies (or colors). Although the absorption frequencies of these two isotopes differ only by a very small amount, the dye lasers used in AVLIS can be tuned so that only the U-235 atoms absorb the laser light. In the vaporizer, metallic uranium is melted and vaporized to form an atomic vapor stream. The vapor stream flows through the collector, where it is illuminated by the precisely tuned laser light. The AVLIS laser system is a pumped laser system comprised of one laser used to optically pump a separate dye laser, which produces the light used in the separation process. A total of three colors are used to ionize the U-235 atoms.

Many countries are pursuing some level of AVLIS research and/or development, and major programs exist in the United States, France, Japan, and probably Russia. Principal advantages of the AVLIS process include a high separation factor, low energy consumption (approximately the same as in the centrifuge process), and a small volume of generated waste. However, no country has yet deployed an AVLIS process, although several have demonstrated the capability to enrich uranium with the process.

Molecular Laser Isotope Separation

The idea for the molecular laser isotope separation (MLIS) process was conceived by a group of scientists at the Los Alamos National Laboratory in 1971. There are two basic steps involved in the MLIS process. In the first step, UF_6 is irradiated by an infrared laser system operating near the 16 mm wavelength, which selectively excites the U-235 atom, leaving the U-238 atoms relatively unexcited. In the second step, a laser system (infrared or ultraviolet) is required for conversion and separation.

There is currently no known MLIS optical system designed to handle both infrared and ultraviolet bands. Consequently, most MLIS concepts use an all infrared optical system, which has not proven to be effective.

There are many complexities associated with the process, and the United States, United Kingdom, France, and Germany have stated that their MLIS programs have been terminated. Japan also has had a small MLIS program.

Chemical and Ion Exchange

Chemical-exchange isotope separation requires segregation of two forms of an element into separate but contacting streams. For heavy elements such as uranium, achieving a suitable separation factor involves contact between two valence (oxidation state) forms. The U-235 isotope exhibits a slight preference for the higher valence in the laboratory. At present, no country has built or operated a full-scale uranium-enrichment plant based on an exchange process, but research continues in technologically advanced countries.

Plasma Separation

The plasma separation process (PSP) has been studied as a potentially more efficient uranium-enrichment technique that makes use of the advancing technologies in superconducting magnets and plasma physics. The only countries known to have had serious PSP experimental programs are the United States and France.

Proliferation Issues

Enrichment technology is not widely available, but electromagnetic separation methods have been declassified. Europe's URENCO, a British, German, and Dutch consortium established in the 1970s to enrich uranium primarily at a plant in Almelo, Netherlands, found that its centrifuge technology was compromised when a Pakistani scientist working there returned to Pakistan with in-depth knowledge of the process. URENCO makes some information available on its website, as it sells its services as a light-water reactor fuel producer.

Any country pursuing nuclear weapons has to use one of the technologies listed above to enrich uranium. Although most of these processes can be detected on the basis of building size or cooling towers for heat dissipation, some programs have surprised the West. An increasing large "gray market" allows nations to purchase only technologies and then acquire scientists and engineers to improve or refine the process. Iraq's work with EMIS, only discovered at the conclusion of the 1991 war at Tarmiya, shocked the world. The Iraqis were still a few years away from full-scale production, but the scope of their program and their successful acquisition of technology had gone undetected. South African, Argentinian, and Brazilian efforts were more conventional. Pakistan, too, managed some technological shortcuts via acquisition of material and know-how to enrich uranium to bomb fuel, and Iran also has managed to acquire technology and know-how from the gray market.

—Gilles Van Nederveen

See also: Manhatten Project; Nuclear Fuel Cycle; Reactor Operations

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ENTRY INTO FORCE

The term "entry into force" refers to the point in time when the provisions of a treaty become legally binding on the parties. It is rare for an arms control agreement to come into force immediately upon signing the document. It more often occurs at a later point in time. Usually, after signature a treaty becomes subject to approval by the respective legislatures or other domestic approval processes of the countries signing the agreement. In the United States, this function is reserved to the Senate. The terms of a given treaty will often specify that the treaty will enter into force "upon the exchange of instruments of ratification."

Instruments of ratification are documents, usually signed by the head of government or head of state, attesting to the approval of ratification by the given country's government. Once all the parties to a given treaty have ratified it through whatever process is dictated by their own constitutions—a process which may take several years—the parties to a given treaty will meet at an agreed place and time and exchange these instruments of ratification, thus bringing the terms of the treaty into force. In the meantime, customary international law obligates the signatories not to do anything that might undermine the "object and purpose" of the agreement, pending its ratification and entry into force.

In the case of most multilateral arms control agreements, it is usually necessary for some number of signatories, or certain specified signatories, to ratify the agreement before it is allowed to enter into force. For example, the Comprehensive Test Ban Treaty, opened for signature on September 24, 1996, must be ratified by forty-four specified countries before it can come into force. By 2003, only thirty-one had ratified the treaty.

—Kerry Kartchner

See also: Arms Control; Comprehensive Test Ban Treaty

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EQUIVALENT MEGATON

The destructive power of nuclear weapons often is represented by a measure known as "equivalent megatons" (EMTs). EMT is obtained by multiplying the raw blast yield (megatons) by 0.66. EMT is a useful measure of the ability of nuclear weapons to destroy soft targets like cities and can help planners determine whether to launch barrage-attacks against large areas (such as operating areas for mobile missiles).

For intermediate blast overpressures needed to destroy soft targets such as mobile missiles, the lethal radius of a nuclear weapon increases by approximately one-third the power of the yield. The lethal area of blast overpressure thus changes by about two-thirds the power of the yield. The area that can be barrage-attacked by nuclear weapons is about equal to the number of warheads times two-thirds the power of the yield. When measured in EMT, larger numbers of small nuclear warheads actually are more destructive than a few large nuclear weapons. Because it takes roughly eight times the raw yield to double the destructive blast damage from a nuclear device, EMT better reflects the "equivalent lethality" that can be achieved by substituting several small nuclear weapons for one large one when used against all but the hardest targets. Four 1-megaton nuclear warheads, for instance, have the same EMT as one 8-megaton nuclear warhead.

—James J. Wirtz

See also: Megaton

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ESCALATION

Escalation is the intensification of conflict along one or more of three axes: the level of violence or the means employed, the geographic scope of combat operations, or the tempo of operations. These factors are sometimes referred to, respectively, as vertical escalation, or the transition from conventional to nuclear war; horizontal escalation, or the spreading of conflict to a greater number of theaters of operation; and temporal escalation, or an increase in the speed or tempo of combat operations. "Horizontal escalation" also can refer to the proliferation of nuclear, chemical, biological, or ballistic missile weapons to a greater number of countries. The term "escalation" also refers to the process by which previous limits in a war (involving any of the three criteria noted above) are crossed and new ones established.

During the Cold War, considerable academic and policymaking attention was devoted to understanding the dynamics of nuclear escalation; that is, the decision to begin employing nuclear weapons, or to "cross the nuclear threshold," in a conflict that has otherwise been limited to combat with conventional military weapons. This process was most fully elaborated by Herman Kahn, a prominent defense analyst in the 1960s. He developed a notional "ladder of escalation" and identified a series of rungs on that ladder to help identify potential limits, or "firebreaks." See Figure E-1 for a summary of Kahn's escalation ladder. According to Kahn and other theorists, "firebreaks" are those theoretical points in an escalation process at which either or both sides have built-in opportunities to reassess the escalation dynamic and to either restrain further escalation or increase the level, scope, or tempo of the conflict.

Figure E-1: A Summary of Herman Kahn's Escalation Ladder with Six Key Thresholds

Nuclear strikes against population centers
City Targeting Threshold
Nuclear strikes against military targets
Central War Threshold
Limited strikes intended to deter further escalation
Central Sanctuary Threshold
Limited local nuclear attacks and countermeasures
Nuclear Use Threshold
Breaking off diplomatic relations, conventional war
Nuclear War Is Unthinkable Threshold
Shows of force, mobilization, confrontation
Don t Rock the Boat Threshold
Subcrisis maneuvering

Source: Herman Kahn, *On Escalation: Metaphors and Scenarios* (New York: Praeger, 1965)

A number of other terms are associated with the process of escalation. "Escalation control" refers to efforts to stop or slow the escalation of a crisis or conflict from increasing further in terms of the level, scope, or tempo of violence. According to the theory of escalation control, demonstrating flexibility and restraint by withholding strikes from certain targets, introducing pauses into the escalation process, or otherwise exploiting opportunities to show an opponent that one is stopping short of an all-out response will maximize the chances that the opponent will reciprocate this restraint, thus bringing the process of escalation under control. The success of such efforts derives from the ability to control one's own forces throughout the escalation process through effective and redundant command and control. It depends, as well, on having forces that are capable of selective, limited, and restrained strikes.

"Escalation dominance" refers to the ability of a side to dominate its opponent at any given rung on the escalation ladder, or at any point along either the vertical, horizontal, or temporal axis of escalation. In theory, if an opponent is aware of the other side's ability to win a conflict at successively higher rungs on the escalation ladder, it will be deterred from taking actions that would escalate the conflict. Deterrence would therefore come into play. Escalation dominance differs from escalation control in that it does not rely on reciprocal restraint on the part of one's opponent.

"Inadvertent escalation" refers to a dynamic escalation process that is precipitated by accident, misperception, or miscalculation, where neither side intended to escalate a conflict nor crisis but feels compelled to respond to an event by increasing the level, scope, or tempo of conflict. Others describe inadvertent escalation as incidents in which military forces begin to operate out of, or beyond the control of, higher political authorities. For example, one or both sides in a conflict or intense crisis might respond to an incident, such as the accidental detonation of a nuclear device or inadvertent launch of a ballistic missile, by launching a retaliatory strike that leads to escalation, or may act on the basis of a misperception or miscalculation, such as mistaking the launch of a peaceful space booster or weather sounding rocket for an offensive military strike. The United States and Russia have established a number of communication links and protocols designed specifically to prevent such incidents from leading to inadvertent escalation, such as the 1963 Hot Line Agreement and the 1972 Incidents at Sea Agreement.

—Kerry Kartchner

See also: Crisis Stability; Firebreaks; Horizontal Escalation; Inadvertent Escalation

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ESCALATION DOMINANCE

See Escalation

ESSENTIAL EQUIVALENCE

The term "essential equivalence" emerged within U.S. political debates during the Strategic Arms Limitation Talks (SALT I) of the late 1960s to describe the key U.S. objective: maintaining strategic nuclear parity (defined as an absence of unilateral advantage for either side). Essential equivalence was based on the notion that the United States and the Soviet Union had developed nuclear weapons along broadly similar lines. Because of technological, political, and geographic differences, however, Soviet and U.S. strategic forces also exhibited important differences. Thus, given the disparity in the quantity and quality of both states' forces, any successful arms control agreement designed to stabilize the strategic situation could not settle on equal numbers but would have to be based on roughly equivalent forces.

According to U.S. Secretary of Defense James Schlesinger, such equivalence was important for two reasons. First, essential equivalence would preserve the situation of mutual assured destruction (*see* Mutual Assured Destruction) without either side gaining a distinct military advantage. Second, strategic nuclear weapons were a symbol of superpower status. Therefore, an absence of equivalence might lead to serious diplomatic or military miscalculation that could lead to war if one side believed that it had somehow obtained a decisive advantage over its nuclear-armed adversary.

SALT negotiators confronted a significant problem, however, when it came to establishing standards for essential equivalence. Measuring equivalence is a highly subjective matter. Criteria by one group of observers to assess equivalence might suggest that strategic parity exists, while equally reasonable criteria adopted by other observers might lead them to believe that a dangerous imbalance in strategic forces exists. Some observers might focus on the accuracy, yield, or throw weight of an arsenal to assess its capability, whereas others might be more interested in assessing survivability. Debate over essential equivalence became so heated in the United States that the U.S. Congress demanded that the Strategic Arms Reduction Treaties (START I and II) be based not on essential equivalence, but on numerical parity.

—Andrew M. Dorman

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EUROPEAN ATOMIC ENERGY COMMUNITY (EURATOM)

The European Atomic Energy Community (EURATOM) was founded to support the development of the nuclear power industry across the entire European Economic Community (EEC), now the European Union (EU), by procuring nuclear material and by using inspections to enforce safeguards at civilian nuclear facilities. All European Union states are automatically members of EURATOM.

EURATOM was established by the Treaty of Rome in 1957. It was created to foster a civil nuclear fuel cycle industry in response to the fear that the demands of the Cold War might cause uranium to be in short supply. The EURATOM Supply Agency (ESA) has operated since 1960 to ensure the supply of ores by means of a common supply policy based on the principle of equal access to sources with the right of option to acquire ores, source materials, and special fissile materials produced in the EU.

EURATOM is the official owner of all nuclear materials in all EU countries. The exception to this rule, however, occurs when producers retain responsibility for the storage or disposal of special fissile materials (plutonium and highly enriched uranium). It also has the exclusive right to validate contracts dealing with nuclear materials made by utilities located in the EU. The export of special fissile materials outside of the EU can only be undertaken by the ESA with the approval of the EU Commission. EURATOM maintains safeguards and inspections to ensure that no diversion of nuclear materials takes place "for other than intended uses." EURATOM thus permits use of nuclear materials in military applications. In this way it contrasts with the International Atomic Energy Agency (IAEA), which regulates peaceful uses of atomic energy. The IAEA has no right to engage in any monitoring activities or to conduct inspections in EU nuclear weapon states other than at selected facilities on a voluntary basis (*see* International Atomic Energy Agency).

There are no reactors under construction in the European Union. Only Britain and France are declared nuclear weapon states, and they are in the process of reducing their nuclear arsenals. Furthermore, no other EU state is seeking to develop nuclear weapons. Seven EU states do not have nuclear power, and four that currently possess a nuclear power industry have embraced the political objective of phasing out their nuclear power programs. Fourteen of the fifteen EU states have rejected any growth in civil nuclear capacity, which stands in stark contrast to EURATOM's original objective of promoting the development of nuclear power for peaceful purposes.

EURATOM offers loans for the construction of nuclear power plants in EU accession countries and states that were once part of the Soviet Union. Safeguard agreements with the IAEA will be changed in the EU accession states. In the future, the IAEA will only verify EURATOM inspections.

—*Glen M. Segell*

See also: Reactor Operations; Safeguards

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EXTENDED DETERRENCE

Extended deterrence is the act of providing security for another state through the threat of punishment against a third party. For the North Atlantic Treaty Organization (NATO), the American guarantee of extended deterrence has provided the basis for security against aggressors, particularly the Soviet Union. During the Cold War, deterrence was often equated with nuclear weapons. Today, NATO and other U.S. allies around the world rely on continuing promises of deterrence based on America's nuclear arsenal as the ultimate guarantor of their security.

Deterrence (the prevention of action through fear of the consequences) involves a state of mind brought about by the existence of a credible threat of unacceptable counteraction. Extended deterrence is exercised by threatening action or reaction against a third party in an attempt to convince that party not to take some action. This reaction includes, in extreme circumstances, the actual use of military power. The aim of deterrence is to pose the prospect of failure or destruction to a potential attacker. Extended deterrence is simply a geographical extension of this concept.

The U.S. nuclear arsenal was designed and deployed in a manner that would provide credible security guarantees to allies. The United States extended deterrence by making it clear that it would, if necessary, use nuclear weapons in response to a Soviet nuclear or conventional attack on allies, especially in Europe and Japan. Although the United States, together with its NATO allies, sought to deploy a conventional force posture that could avoid an early resort to nuclear weapons, the alliance did not forgo the option of first use of nuclear weapons if needed. The extended deterrence concept (sometimes called "active deterrence" because it involves a clear decision and willful act on the part of the nation that owns the weapons and extends its deterrence) underscored the coupling between the United States and its allies (*see* Coupling). It existed in a strategic setting in which the United States extended an explicit security guarantee to its allies, backed by vast nuclear and conventional military capabilities and the forward deployment of hundreds of thousands of U.S. troops and their families in Europe and Asia. In a crisis, deterrence involved signaling the U.S. commitment to a particular country or an alliance and expressing national interest by enhancing warfighting capabilities in the theater. In short, extended nuclear deterrence gave the United States and its allies the confidence to stand toe to toe with potential adversaries and not blink.

History and Background: Europe

Nuclear weapons became an integral part of NATO strategy in 1954 when the United States, facing superior Soviet conventional forces in Europe, first threatened "massive retaliation" against the Soviet Union in the case of a Soviet attack against Western Europe. By so doing, the United States "extended" deterrence to its European allies against a Soviet attack and created what also was referred to as a "nuclear umbrella" sheltering Western Europe. America's nuclear guarantee was backed up by the deployment of some 250,000 U.S. troops and their families to Europe. This substantial U.S. presence in Europe served as a "tripwire" ensuring American vulnerability to an attack against Western Europe, thereby providing the linkage to U.S. strategic nuclear forces.

By the early 1960s, the credibility of the massive retaliation threat was called into question when the Soviet Union achieved the ability to also hit U.S. cities with its nuclear weapons (*see* Credibility). Therefore, in 1967, the allies agreed to replace "massive retaliation" with "flexible response," a doctrine designed to give NATO a variety of nuclear and conventional force responses to a Soviet attack. The discussion over whether to adopt flexible response drove France out of NATO's military arrangements in 1966 (*see* Flexible Response; Massive Retaliation).

According to early alliance documents, it was clear that both the United States and the European allies understood that the U.S. security commitment to Europe included nuclear protection against coercion or aggression. Much of NATO's history has been marked by debates over the meaning of this nuclear guarantee. During the Cold War, Europe's leaders reached consensus that a U.S. nuclear presence on the ground in their countries was a requirement for credible extended deterrence.

Nuclear weapons, particularly tactical or theater weapons, were the next logical step above conventional forces on the escalatory ladder of conflict and thereby provided a link—"coupling"—to the United States (*see* Escalation). To this purpose, nuclear weapons had to be flexible, survivable, have sufficient range, and have a doctrine for their use. Also, allied participation in planning and deterrence through threatened use helped assuage potential desires for independent nuclear capabilities and made Washington's NATO allies feel a part of the shared risk and responsibilities.

The deployment of U.S. short- and medium-range missiles that could hit Soviet territory from locations in Western Europe was meant to convince the Soviet Union that a war in Europe could not be kept at the conventional level. Escalation would put Soviet territory at risk, too, thus raising the stakes for Russia. Unlike strategic forces, intermediate-range missiles would become vulnerable to preemptive attack early in a European war, potentially forcing the destabilizing decision to use these weapons early rather than risk losing them to capture or destruction.

A question arose regarding the ultimate political purpose of nuclear weapons in Europe: Were they there to provide deterrence, or to reassure America's allies? Obviously they served both purposes. Coupling the United States to Europe created a condition where the integrity of the chain of escalation was complete, from conventional forces in Europe, to theater nuclear forces in theater, to the U.S. strategic nuclear force. This symbolized the social, political, and historical links between the two sides of the Atlantic. A challenge, however, resulted from the geographical separation of Europe and the United States and the uncertainty that separation engendered in the minds of European allies. This was one aspect of "NATO's nuclear dilemma."

Europeans suspected and feared that the United States *could,* in the event of crisis or war, decouple itself from Europe's problems. Every move made by the alliance since the 1960s, as U.S. nuclear superiority ended, that involved nuclear forces or strategy reinvigorated this worry about "the specter of decoupling."

This question revolved around the deliberately ambiguous strategy of flexible response. This strategy marginally satisfied both parties, but only because of its doctrinal ambiguity. Europeans focused on the response side of the equation (deterrence by punishment) and the "seamless web" of deterrence; the United States, in contrast, focused on flexibility and deterrence by denial (a warfighting approach).

If conflict were to break out in Europe, it was reasoned, the United States and Europe would have different responses. The United States would favor a limited war confined to the Continent, would want to prevent its spread to North America, and would want to keep it conventional as long as possible. This approach reflected its warfighting preference. Tactical nuclear weapons stationed (and, if necessary, used) in Europe would serve these warfighting strategies. Europeans, who did not want to see any type of war break out on their soil, preferred a policy of immediate, catastrophic, automatic escalation to nuclear war at the highest possible level, thereby increasing the level of deterrence effect. They feared that if war broke out, it could be fought "over their heads" and that the American preference for smaller tactical weapons could be destabilizing.

Both points of view therefore called for European-based nuclear weapons in NATO's arsenal, though for different reasons. These weapons supported both types of deterrence—one directly, one indirectly. Neither perspective justified nuclear weapons in terms of reassurance, but they were reassuring nonetheless, especially in light of the transatlantic linkage argument, which Europeans stressed. Thus a constituency arose on both sides of the Atlantic that wanted nuclear weapons in Europe. There has been little change in the underlying rationale for nearly fifty years. It is a sensitive topic, however, and the issues relating to it are normally kept out of the public eye.

Deterrence in Other Regions

Nuclear weapons did not ensure the end of war, but they did appear to limit the size of the conflicts that occurred "underneath the nuclear umbrella." It is hard to say whether nuclear deterrence succeeded, since deterrence can only be assessed if it fails. But the lessons of Europe appeared compelling and were thought to be transferable elsewhere in the world.

America's extended nuclear deterrence to Japan was implied; in South Korea the guarantee was blatant (with nuclear weapons deployed in Korea until 1992). The United States also implied that it would defend Israel with nuclear weapons (until Israel developed its own nuclear forces). These guarantees were backed up by multiple regional alliances, including NATO, ANZUS (the Australia-New Zealand-U.S. alliance), SEATO (the Southeast Asia Treaty Organization), and CENTO (the Central Asian Treaty Organization).

The Future

American extended deterrence rests on a combination of conventional and nuclear retaliatory capabilities, active and passive defenses, and counterforce policies. Notwithstanding consistent allied declarations concerning NATO strategy and the continued importance of U.S. substrategic weapons deployed in Europe, a number of questions may be posed. The most basic issue is whether a U.S. nuclear guarantee for European security is still essential and, if so, how to implement that guarantee.

The region that may most need America's extended deterrent is East Asia. American allies in the region feel and fear the ripple effects of multiple simultaneous strategic changes: North Korea's nuclear aspirations; China's growth into a regional hegemon with the potential for strategic military capabilities that match its economic strength; instability in states such as Indonesia; and the ongoing competition between India and Pakistan. All of this points to greater uncertainty and raises the specter of new threats to traditional allies such as Japan, South Korea, and Taiwan. The strategic defense leg of the new U.S. strategic "Triad" (*see* Triad), rather than the offensive nuclear approach that NATO took in Europe, may be appropriate for these states.

A recent RAND Corporation study listed a number of ways in which the United States could increase the credibility of its regional deterrent:

- Increase the perception of U.S. resolve through traditional diplomatic and military activities
- Extend security commitments to regional allies
- Station troops overseas in a crisis
- Emphasize U.S. military capabilities to impress adversaries
- Deploy theater defenses to make the U.S. homeland less vulnerable to WMD attack. (Wilkening and Watman)

These points suggest several conclusions about the future of American nuclear strategies to ensure viable extended deterrence. Such strategies should strive not only to maintain traditional nuclear deterrence for U.S. allies but also to protect U.S. forces overseas from weapons of mass destruction (WMD). Nuclear weapons assume a less central but still important role. Conventional weapons also have a role to play, as do overseas basing decisions and access capabilities.

All of these measures are based on one key assumption: that the United States retains its role as the leading great power in the world, with commensurate global responsibilities.

—Jeffrey A. Larsen

See also: Cold War; Deterrence; Minimum Deterrence; North Atlantic Treaty Organization

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F

FAILSAFE

During the Cold War, the term "failsafe" referred to the turnaround point for nuclear-armed strategic bombers flying airborne alert; that is, the decision point en route to the target at which the crew members would have to decide whether to proceed forward with their mission and bomb their targets in Eastern Europe and the Soviet Union, or turn around and head for home. In the absence of positive orders to the contrary, they would turn around—in other words, in the absence of a positive order to proceed with their mission, negative control of nuclear release authority would prevail, and the bombers would return to base. "Failsafe" entered the popular lexicon as a word symbolizing the concern during the Cold War that strategic nuclear war would erupt owing to mechanical or human error or inadvertent escalation during a crisis.

A book with the title *Failsafe* was released in 1962 and made into a best-selling movie the following year. Written by Eugene Burdick and Harvey Wheeler, it was based on the 1958 book *Red Alert* by Peter Bryant. The premise in *Failsafe* was that a rogue commander of a U.S. bomber wing uses a false message to send his fleet of B-52s past their failsafe points. His hope is to force the president, once he realizes that there is no calling the bombers back, to follow through with the full might of the U.S. arsenal while it has strategic superiority, thus ending the Cold War standoff once and for all. As things turn out in the story, one bomber gets through and destroys Moscow, and the president decides to destroy New York, using an American bomber, to show the Soviets that the United States is sincerely sorry about the incident, thereby preventing a massive nuclear exchange between the superpowers. Its message was distinctly antiwar and reflected the apocalyptic attitudes prevalent during this era.

A 1964 spoof on this serious subject was made into another motion picture. *Dr. Strangelove: Or How I Learned to Stop Worrying and Love the Bomb* followed much of the script from *Failsafe,* but with a dark comedic approach that satirized Strategic Air Command and the logic of deterrence theory, mutual assured destruction, and the quasi-religious approach to nuclear weapons.

—*Jeffrey A. Larsen*

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FALLOUT

The term "fallout" refers to radioactive particles created from the tons of soil and debris irradiated by a nuclear detonation. This material is scooped up and carried into the mushroom cloud of the explosion, and the particles return to the Earth's surface as fallout.

When the fireball from a nuclear detonation touches the Earth's surface, it forms a crater. The earth from this crater is pulverized into microscopic, radioactive particles by the force of the explosion. These particles, along with surface structures pulverized by the explosion, are carried up into the distinctive mushroom-shaped cloud created by the detonation and eventually fall out of the cloud and return to the Earth's surface. Each contaminated particle continuously emits radiation while in the mushroom cloud, while descending, and on the ground. There are two categories of fallout: early and delayed. Early fallout descends to Earth within twenty-four hours after the explosion. Delayed fallout arrives after this twenty-four-hour period.

The largest, heaviest fallout particles reach the ground first, landing in locations close to the explosion. The smaller particles could be carried by the wind for hundreds of miles before falling to Earth. Additionally, they fall so slowly that most could remain airborne for weeks to years before reaching the ground. By that time, their dispersal and radioactive decay would make them much less dangerous. The radioactive particles that rise only a short distance (those in the "stem" of the mushroom cloud) will fall back to earth within a matter of minutes and land close to ground zero (the focal point of the detonation). Such particles are unlikely to cause many deaths because they will fall into areas where most people have already been killed by other nuclear weapons effects. The radioactivity contained in this fallout, however, will complicate rescue and recovery operations. The particles that rise higher in the cloud will be carried some distance by the wind before returning to earth.

The area and intensity of the fallout is strongly influenced by local weather conditions. Much of the material is simply blown downwind, forming a plume-shaped pattern on the ground. Rainfall also can influence the way fallout is deposited, since rain will carry contaminated particles to the ground. The areas receiving such contaminated rainfall become "hot spots," with greater radiation intensity than their surroundings.

A nuclear explosion creates four kinds of radiation: alpha, beta, gamma, and neutron. Gamma radiation is by far the most dangerous because its rays are more penetrating and harmful. The roentgen (R) is the unit most commonly used to measure gamma radiation. Most American civil defense instruments give readings in roentgens or roentgens per hour (R/hr). Until 1980, the U.S. military used the rad (radiation absorbed dose) as its unit of measurement. It now uses gray (Gy), for interoperability with the North Atlantic Treaty Organization (NATO). The danger from fallout radiation lessens with time. The radioactive decay, as this lessening is called, is rapid at first, and then becomes slower. The dose rate (the amount of radiation received per hour) decreases accordingly.

—Jeffrey A. Adams

See also: Airborne Alert; Cold War; Half-Life; Nuclear Weapons Effects; Radiation

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FAST BREEDER REACTORS

The fast breeder reactor (FBR) is a type of nuclear reactor that uses fast, or high-energy, neutrons to cause fissions. It can produce more fuel nuclei than are consumed in the fission process and can thus substantially extend the supply of nuclear fuel.

The first breeder reactor, designed by the Argonne National Laboratory in Illinois, became the first reactor of any type to generate electricity when it went on line in 1951. The development of FBRs gave impetus to the prospect of using nuclear fuel as a long-term energy source. In April 1977, President Jimmy Carter decided that the United States would not reprocess and recycle plutonium from commercial reactors; this decision effectively curtailed the development of commercial breeder reactor technology by the United States.

Fissile isotopes, including uranium 235 (U-235) and plutonium 239 (Pu-239), fission readily when struck by low-energy neutrons (*see* Isotopes). Other isotopes, including the much more naturally abundant U-238, readily fission only when struck by fast neutrons. The development of the fast reactor is an attempt to exploit the potential of the most abundant uranium isotope, U-238. The U-238 in the fast reactor can capture a neutron and convert it into Pu-239, a fissile isotope. This plutonium can then be reprocessed and used as fuel in another reactor. A breeder reactor breeds fuel by producing more fissile nuclei, through neutron capture, than are consumed in fission.

FBRs are not currently operating in the United States, although other nations, such as Japan and France, operate research FBRs. The fear that the Pu-239 produced in the reactor would somehow manage to find its way into clandestine nuclear weapons programs, plus the difficulty of working with liquid sodium, often used as the reactor coolant, has caused many countries to discontinue their plans to build commercial FBRs.

—Brian Moretti

See also: Reactor Operations

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FAT MAN

On August 9, 1945, the United States targeted Nagasaki, Japan, with the second atomic bomb to be used against an adversary in wartime. Dropped by a B-29 bomber, *Bockscar,* the weapon was nicknamed "Fat Man" by its designers because of its large size, which was necessary to accommodate the early implosion design. Fat Man was detonated three days after the first atomic bomb, "Little Boy," was dropped on Hiroshima, and Japan had not yet responded to President Harry S. Truman's call for unconditional surrender. The combined devastation of these two weapons is credited with hastening the end of the war with Japan and ushering in an atomic age.

In Fat Man, a sphere of plutonium 239 (Pu-239) was compressed by many timed, simultaneous chemical explosive charges. The implosion of the subcritical sphere increased the density of the plutonium to a supercritical state. Additionally, an initiator that produced an initial burst of neutrons was centered in the sphere to increase the rapidity of the fissile chain-reaction. To lengthen the time of the reaction, a "tamper" of uranium 238 (U-238), a very strong material, held the components together long enough to ensure that a sufficient amount of Pu-239 could fission and release enough energy to create a blast. Neutron reflectors surrounded the device to further feed the nuclear reaction, thus maximizing the explosive power. The sophistication of the implosion device was greater than that of Little Boy's gun-type device, and so testing before use was considered necessary. The first atomic explosion in history, at the Trinity Site in New Mexico three weeks before Little Boy was dropped on Hiroshima, had used an implosion device similar to the one in Fat Man.

—Jennifer Hunt Morstein

See also: Fission Weapons; Implosion Devices; Little Boy; Nagasaki; Nuclear Weapons Effects; Trinity Site

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FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

The U.S. Federal Emergency Management Agency (FEMA) was once an independent agency tasked with responding to, planning for, aiding recovery from, and mitigating disasters. FEMA became part of the newly created U.S. Department of Homeland Security in March 2003.

FEMA can trace its beginnings to a congressional act of 1803. An early piece of disaster legislation, it provided assistance to a New Hampshire town following an extensive fire. Over the next century, adhoc legislation was passed by Congress scores of times in response to natural disasters.

By the 1970s, federal emergency and disaster response duties were shared by many agencies. When the full range of hazards associated with nuclear power plants, transportation of hazardous substances, and natural disasters were combined, more than 100 federal agencies were involved in responding to emergencies. The National Governor's Association, seeking to decrease the many agencies with which state and local governments were forced to work, asked President Jimmy Carter to centralize federal emergency functions.

President Carter's response was a 1979 executive order merging many of the separate disaster-related responsibilities into a new Federal Emergency Management Agency. FEMA incorporated the Federal Insurance Administration, the National Fire Prevention and Control Administration, the National Weather Service Community Preparedness Program, the Federal Preparedness Agency of the General Services Administration, and the Federal Disaster Assistance Administration activities from the Department of Housing and Urban Development. The Defense Department's Defense Civil Preparedness Agency also transferred responsibility for civil defense in the event of nuclear war to FEMA. FEMA developed an Integrated Emergency Management System to respond to the challenges created by a range of natural and manmade disasters. With the end of the Cold War in the early 1990s, FEMA redirected resources from civil defense into disaster relief, recovery, and mitigation programs.

The terrorist attacks of September 11, 2001, focused FEMA on issues of national disaster preparedness and homeland security. The agency coordinated its activities with the newly created White House Office of Homeland Security, and FEMA's Office of National Preparedness was given responsibility to ensure that the nation's first responders could cope with incidents involving weapons of mass destruction. FEMA also moved funding directly to local communities to help them face the threat of terrorism. A few years past its twentieth anniversary, FEMA was directing its "all-hazards" approach to disasters toward homeland security issues.

In March 2003, FEMA joined twenty-two other federal agencies, programs, and offices in forming the Department of Homeland Security. FEMA is one of five major branches of the department. About 2,500 full-time employees in the Emergency Preparedness and Response Directorate are supplemented by more than 5,000 stand-by disaster reservists (*see* Department of Homeland Security).

—Steven Rosenkrantz

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FEDERATION OF AMERICAN SCIENTISTS (FAS)

The Federation of American Scientists (FAS) is the oldest organization dedicated to what its members believe is an ongoing, worldwide arms race that could result in the use of nuclear weapons. It was founded in 1945 as the Federation of Atomic Scientists by alumni of the Manhattan Project who were deeply concerned about how nuclear weapons threatened the future of humankind.

FAS, known in its early years as the "scientists' lobby," is a nonprofit, nongovernmental organization (NGO) that offers analysis and opinion about a range of science, technology, and public policy issues. During the FAS presidency of Jeremy J. Stone (1970–2000), the NGO expanded its membership and staff by addressing new issues such as energy conservation and the environment, areas previously outside of its traditional focus on international security. Stone gave FAS a higher profile internationally by working to encourage scientific exchange with the People's Republic of China after President Richard M. Nixon's 1972 visit to China and by devising solutions to technical obstacles during the U.S.-Soviet Strategic Arms Reduction Treaty (START I and II) of the late 1980s and early 1990s. In the human rights arena, Stone and FAS supported Soviet dissident Andrei Sakharov in the 1970s and 1980s, and it lobbied in the late 1980s and early 1990s to help prevent the Khmer Rouge's return to power in Cambodia.

FAS offers a scientific perspective on contemporary public policy issues through lobbying and advocacy, expert testimony, briefings with policymakers and the press, and public education and outreach. It often collaborates with civil rights, human rights, and arms control groups.

—Steven Rosenkrantz

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FIREBALL

See Nuclear Weapons Effects

FIREBREAKS

"Firebreaks" were theoretical rungs on the Cold War escalatory ladder that provided opportunities to demonstrate to all concerned the seriousness of a situation. As the concept of mutual assured destruction (MAD) began to emerge between the United States and the Soviet Union in the early 1960s, analysts attempted to devise both political and warfighting strategies to make nuclear weapons militarily relevant on the battlefield and politically relevant in superpower relations. Drawing on game theory, several analysts, led by the Harvard economist Thomas Schelling, came to believe that nuclear threats, or the actual detonation of a nuclear weapon, could be used for purposes of intrawar deterrence, bargaining, and signaling. Schelling conceived of deterrence, and the nuclear infrastructure and arsenal that supported it, as creating a "threat that leaves something to chance" (Schelling 1960, p. 188); that is, nuclear threats and limited nuclear use created a distinct path to nuclear Armageddon that no one wanted. The side willing to run the greater risk of a full-scale nuclear exchange, however, would have a distinct advantage during a crisis or in wartime, which in theory would force the less committed party to back down.

Theory and practice suggested that it was possible to communicate with other parties without verbal or written communication, even during wartime. In other words, certain types of events had clearly implied messages, and these messages were plain for all to see regardless of culture, history, or ideology. In the literature on nuclear war, these "firebreaks," or key rungs on the escalation ladder, demonstrated to all concerned the seriousness of the situation. Opponents theoretically recognized when an adversary was holding violence below a firebreak or crossing a threshold and would respond accordingly. The most important firebreak was the outbreak of war itself. Another key firebreak was the first use of a nuclear weapon by either side. A distinction also could be made between attacks on the home territory of either superpower or attacks against allies or client states. Herman Kahn, a leading nuclear theorist in the 1960s who developed several schemes to classify the process of escalation, identified six crucial firebreaks: (1) don't rock the boat; (2) nuclear war is unthinkable; (3) no nuclear use; (4) central sanctuary; (5) central war; and (6) city targeting. Kahn's escalation ladders often ended with a full-scale nuclear exchange, which he described as "spasm war," and once even as "war-gasm."

Theorists who believed in nuclear warfighting suggested that it was wrong to treat war, escalation, and nuclear attacks as an exercise in bargaining and a competition in risk taking. They recognized the existence of firebreaks, but they believed that nuclear war should be prosecuted like a conventional conflict by attempting to find ways to fight and win, or at least to emerge from the conflict better off than the opponent. They believed their view was vindicated by the U.S. experience during the Vietnam War. Many believe that the Lyndon B. Johnson administration undertook limited military attacks early in that conflict to signal its resolve and superior military capability to the North Vietnamese, an effort that had little impact on Hanoi's willingness to use military force to achieve its objectives. More recently, the North Atlantic Treaty Organization's 1999 air campaign against Serbia suggested that the threat of additional destruction—the crossing of firebreaks—could be used to coerce opponents to comply with one's political demands.

—James J. Wirtz

See also: Crisis Stability; Escalation; Game Theory; Mutual Assured Destruction

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FIRST STRIKE

A first-strike strategy is a policy and a capability whereby nuclear (or precision-guided conventional) weapons are used to strike first, destroying an opponent's nuclear arsenal before it can be launched in retaliation. A first strike also might involve attacks against an opponent's military and political leadership and command and control infrastructure, thereby decapitating its command leadership and further reducing the likelihood of an effective retaliatory strike.

One of the key U.S. proponents of the first strike was nuclear strategist Herman Kahn. In his seminal 1961 work *On Thermonuclear War,* Kahn argued that the United States should develop such a capability—not to conduct an unprovoked surprise attack against the Soviet Union, but to reinforce deterrence by avoiding a mutual "balance of terror." Kahn suggested that a balance of terror was dangerous because the Soviet Union could exploit the stability-instability paradox by undertaking a conventional thrust across Europe, knowing that any U.S. retaliation raised the prospect of mutual assured destruction (MAD). The U.S. president, faced with the prospect of escalation to a full-scale nuclear exchange, probably would choose not to use nuclear weapons to respond to a Soviet conventional attack on the North Atlantic Treaty Organization (NATO). Kahn suggested that deterrence would be better served if the United States possessed the means to launch a first strike against Soviet nuclear forces in the event that nuclear deterrence had failed or was failing to stop a conventional attack against Western Europe.

The difficulty of actually creating the first-strike capability called for by Kahn in 1961 became obvious as the Soviet and U.S. nuclear arsenals continued to grow in size and quality throughout the

1960s, 1970s, and 1980s. First, the emergence of both a Soviet and U.S. "Triad" of nuclear forces—consisting of land-based intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and long-range heavy bombers—greatly increased the survivability of both sides' retaliatory capability, placing a first-strike capability beyond the reach of both Soviet and American strategists. Placing nuclear forces on high day-to-day alert levels—for example, U.S. Strategic Air Command bombers and command and control aircraft on airborne alert—increased the likelihood that both Soviet and U.S. strategic arsenals possessed a launch-on-warning, or launch-under-attack, capability, greatly reducing the prospects that they would fall victim to a first strike.

The development of effective early-warning and command-and-control systems also reduced the prospects that either side would launch a first strike. The deployment of U.S. and Soviet early-warning satellites enabled both sides to detect the heat from the rockets of ICBMs and SLBMs within 90 seconds of their launch, giving each side up to 30 minutes of warning in an attack. A series of ground-based radar networks would then progressively characterize the attack under way. Emergency evacuation procedures ensured that at least some political and military leaders would survive to authorize retaliation from surviving nuclear forces (*see* Early Warning).

But toward the end of the Cold War, U.S. planners worried increasingly about the vulnerability of command and control to a decapitation attack (*see* Decapitation). Very-high-altitude nuclear detonations could create an electromagnetic pulse (EMP) that would burn out electronic and telecommunications systems, blocking the transmission of orders to nuclear forces. Many also feared that Soviet SLBMs fired at short range on depressed trajectories might kill U.S. political leaders before they could be dispersed or give nuclear release orders. It also was feared that bomber forces could be targeted by depressed-trajectory SLBM attacks, reducing warning time to a few minutes at most and making it less likely that pilots would be able to get bombers off the ground and out to safe escape distances (*see* Depressed Trajectory). Although these potential capabilities did not guarantee that a Soviet first strike would be successful, planners were concerned that the Soviets might think they would have a significant edge in a nuclear war, and that this trend could produce incentives for them to use nuclear weapons first in a crisis.

Since the end of the Cold War, the likelihood of a deliberate Russian attack on the United States has been extremely low. But today, the proliferation of long-range delivery systems and weapons of mass destruction creates incentives for U.S. policymakers to contemplate nuclear and conventional first-strike policies and capabilities to prevent nascent chemical, biological, or even nuclear arsenals from being used first in a crisis or war.

—Malcolm Davis and James J. Wirtz

See also: Second Strike

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FISSILE MATERIAL CUTOFF TREATY (FMCT)

The purpose of a fissile material cutoff treaty (FMCT) is to curb the amount of fissile material available for nuclear weapons by banning production of fissile material for nuclear weapons or other explosive devices. Proposals for an FMCT have been part of international arms control talks since the end of World War II. Almost all variations of FMCT proposals target the activities of the five nuclear weapons states (the United States, the United Kingdom, Russia, China, and France) and the three "threshold states" (Israel, Pakistan, and India). Fissile materials are the fundamental ingredient of all nuclear weapons. They also are the most difficult and expensive part of a nuclear warhead to produce. Consequently, there would be obvious benefits to stopping, or "cutting off," the production of fissile materials. An FMCT would limit the size of potential nuclear arsenals, making reductions irreversible if fissile materials were transferred from dismantled weapons and other unsafeguarded stocks to non-weapons use or disposal under international standards. It would also strengthen the nonproliferation regime by opening nuclear facilities in all nations to some form of international inspection.

An FMCT is generally considered a disarmament initiative because it would eliminate all stockpiles of fissile materials for nuclear weapons or nuclear explosives. Any proposal for an FMCT would include at least three elements: a ban on the production of fissile material; an agreement not to assist other states in such activities; and a verification mechanism or process in which the International Atomic Energy Agency (IAEA) would play a prominent role. An FMCT would not address previously produced stockpiles of fissile materials, nor would it apply to fissile materials not used for weapons systems, such as naval nuclear-propulsion systems. Although there exists no internationally agreed-upon definition of "fissile material," in the context of proposed negotiations on an FMCT the term usually refers to any fissionable material that could be used for a nuclear explosion, that is, "weapons-grade" or "weapons-usable" material. This would include any isotope of plutonium, uranium 233, or uranium enriched to that point that it contains 20 percent or more of the isotope U-235. FMCT proponents generally agree that the proposed "fissile material" ban would not apply to other radioactive materials, nor would it apply to exotic materials such as tritium or americium (*see* Enrichment; Highly Enriched Uranium [HEU]; Isotopes).

There have been several proposals for an FMCT, but there is currently no negotiating text. Although the United Nations Conference on Disarmament (CD) established a mandate to negotiate an FMCT in March 1995, formal negotiations remain stalled. In 1998, the mandate for negotiations expired, and the CD must now agree on a new mandate before any negotiations can begin. A standoff in the CD has developed over the FMCT in a number of significant areas. First, the nonaligned group in the CD has complained that the nuclear weapons states (NWS) have followed an incremental approach to nuclear disarmament through stand-alone treaties and have, in effect, abandoned any effort at a comprehensive approach to disarmament. Many in the nonaligned group, including India and Pakistan, have characterized the Nuclear Nonproliferation Treaty (NPT) of 1968 and a future FMCT as unequal and discriminatory. In their view, such treaties create two classes: the nuclear "have" and "have-not" states. India has argued that these types of treaty-based regimes encourage the monopolization of nuclear weapons by the nuclear weapons states and perpetuate inequality because they fail to address a timetable for disarmament. Intrinsic to this argument is the belief that the FMCT would not represent a significant constraint upon the NWS. Another contentious issue is the scope of a future FMCT. Several in the nonaligned group object to an FMCT focused solely on halting future production, arguing that an FMCT that does not consider past production would translate into a freeze of the status quo.

Negotiations have been further complicated by attempts by several participating states, including Russia and China, to "link" progress on FMCT negotiations to other arms control initiatives. China, for example, linked FMCT to the continuation of the Anti-Ballistic Missile (ABM) Treaty. Then, when the United States terminated the treaty, China continued to insist that no FMCT negotiations could begin until there was a negotiating mandate for talks on the prevention of an arms race in outer space. China and other states also insist on linkage of an FMCT with a timetable for nuclear disarmament. These "linkage" proposals were unacceptable to the United States. Although the United States' first priority in the CD is the negotiation of a comprehensive, effectively verifiable FMCT, it has stated that it will not do so at the expense of agreeing to negotiations on outer space or a timetable for nuclear disarmament, which it has called "not ripe" for multilateral negotiations. Russia agreed that it would not discuss nuclear disarmament but expressed a willingness to negotiate on outer space issues. The UK and France generally have agreed with the U.S. view opposing linkage on these two issues, although on various occasions they have been more amenable to agreeing to "talks" or discussions without a negotiating mandate. Possible alternatives to negotiating an FMCT outside the CD have been proposed, such as having only the nuclear weapons states and threshold states meet to negotiate an agreement, but such proposals have been unable to muster political support.

It is generally assumed that the IAEA would be called upon to conduct verification activities to support an FMCT (*see* Verification). Another key issue, when and if negotiations begin on an FMCT, will be how to verify the absence of clandestine enrichment and reprocessing facilities. In addition to verifying whether fissile material is being sequestered or stockpiled, the IAEA would be called upon to search for and inspect undeclared facilities, which would be subject to either "special" or "challenge" inspections. A special inspection is an inspection that the

IAEA may perform at any site in the territory of a state party, regardless of whether it is declared, on the sole initiative of the IAEA. A challenge inspection is one conducted at the request of another state party. The original mandate for negotiating an FMCT required that any agreement be "effectively verifiable." Given the nature of the materials to be subjected to an FMCT, this point would require intrusive challenge and special inspections anywhere, anyplace, and anytime. For the United States and other nuclear weapons states, this requirement would be difficult to meet, given the need to protect nuclear weapons information, weapon delivery system technologies, commercial proprietary information, information related to highly sensitive naval nuclear-propulsion technology, and other classified information or technology unrelated to nuclear weapons or nuclear technology.

—*Guy Roberts*

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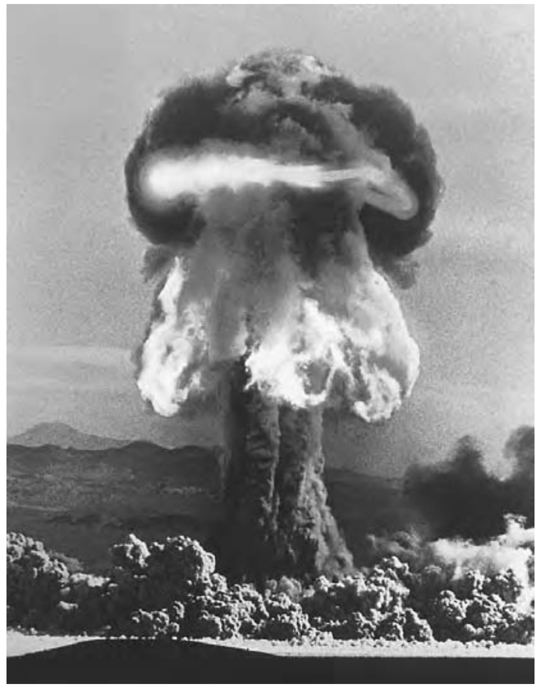

The "Grable" atomic bomb test, May 25, 1953, Nevada Test Site. (Corbis)

FISSION WEAPONS

A fission weapon is a highly explosive device utilizing uranium or plutonium that is brought to a critical mass under pressure from a chemical explosive detonation. It produces significant blast, thermal radiation, and nuclear radiation through fission.

History and Background

In the late 1930s, many scientists around the world were working to achieve a theoretical understanding of a sustained fission reaction, with the idea that it might be possible to build a bomb of tremendous power utilizing the process of fission. Physicists repeatedly brought the idea of an atomic bomb to the attention of the military and other government offices in the United States and Great Britain with no real success.

It was not until December 6, 1941, the day before the Japanese bombed Pearl Harbor, that the decision was taken to begin substantial financial and technical support of a program to produce the bomb. The project became known as the Manhattan Project (*see* Manhattan Project). The primary purpose of the Manhattan Project was not only to produce a workable atomic weapon but to do so before the Germans could develop a nuclear weapon. The physicists and engineers working on the project succeeded in their undertaking at 5:30 A.M. on July 15, 1945, at a spot in the New Mexican desert codenamed Trinity. The fission weapons produced by the Manhattan Project were used twice in war, against Hiroshima, Japan, on August 6, 1945, and on Nagasaki, Japan, on August 9, 1945 (*see* Hiroshima; Nagasaki). Bomb production did not end at the conclusion of World War II. Weapons production continued with new, larger designs. The 500-kiloton Ivy King nuclear test by the United States on November 15, 1952, was probably the largest fission-based nuclear weapon ever detonated. The device exploded in this test was the Mk-18 Super Oralloy Bomb.

Technical Details

The two basic types of fission weapons are the gun and implosion designs. Both types use fissile material, and several designs make use of the fusion of lighter elements to improve weapon efficiency and "boost" the energy release (*see* Fusion). Similar components are present in each design: chemical explosives (or in the case of the gun-type, propellants) to compress the fissile material into a supercritical mass that will sustain an explosive chain reaction; nonfissile materials to reflect neutrons and tamp the explosion; electronics to trigger the explosion; a neutron generator to start the nuclear detonation at the appropriate time; and associated electronic and mechanical safety, arming, and firing mechanisms.

The gun-type weapon is the simplest method for creating a fission weapon. Gun-type designs use uranium 235 or U-233 as the fissile material. The fissile material is kept in the form of two hemispheres, each of which is subcritical, but which when brought together form a supercritical mass. "Tampers," constructed of a heavy material around the fissile material to contain it for the amount of time needed to produce the desired yield and act as a neutron reflector, are located around both hemispheres. The nuclear explosion is initiated by detonating a high-explosive propellant behind one of the hemispheres, which accelerates rapidly down the barrel toward the other. At the instant the two hemispheres meet, a burst of neutrons is injected to initiate a chain reaction.

The primary advantage of the gun-type design is its simplicity. It is as close to a foolproof design as technology allows. The drawbacks to the gun-type design are the lack of compression, which results in a need for large amounts of fissionable material and leads to low efficiency; inefficiency in its use of fissile material, as only about 3 percent of the material is fissioned, on average; a slow insertion speed, which means that only U-235 and U-233 can be used; and the weight and length of the gun barrel, which make the weapon heavy and fairly long. The gun-type design is highly predictable, as was evident by its use in the bomb dropped on Hiroshima without prior testing. The gun-type weapon used at Hiroshima contained about 42 kilograms of 80 percent enriched U-235 and yielded 12.5 kilotons of explosive power.

The implosion-type design makes use of the fact that increasing the density of the fissile material decreases the critical mass required for a supercritical state. This is the principle employed in most modern nuclear weapons designs of the five declared nuclear states. In an implosion design, the fissile material is in the form of a small subcritical sphere surrounded by a tamper. Outside this is a high explosive, which is detonated simultaneously at a number of points on the exterior to produce a symmetrical, inward-traveling shock wave. This "implosion" compresses the fissile material to two to three times its normal density. At the moment of maximum compression, a burst of neutrons is injected to initiate a chain reaction. The primary advantages of the implosion-type design include a high insertion speed, which allows materials with high spontaneous fission rates (that is, plutonium) to be used; a high density, leading to a very efficient weapon and a need for relatively small amounts of material; and the potential for lightweight designs—in the best designs, only several kilograms of high explosive are needed to compress the core.

The principal drawback to the implosion-type design is its complexity and the precision required to make it work. Implosion designs take extensive research and testing and require high-precision machining and electronics. The crucial timing and simultaneous detonation of the high explosives leads to increased concern over the predictability of the yield or even a complete malfunction of the weapon. This is the type of weapon dropped on Nagasaki, but not before it was tested in the New Mexico desert. The implosion-type weapon used at Nagasaki yielded 20 kilotons of blast energy.

—D. Shannon Sentell, Jr.

See also: Criticality and Critical Mass; Deuterium; Gun-Type Devices; Hiroshima; Implosion Devices; Nagasaki; Neutron Bomb (Enhanced Radiation Weapon); Neutrons; Nuclear Weapons Effects; Plutonium; Radiation; Uranium; Yield

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FIZZLE

See Criticality and Critical Mass; Nuclear Weapons Effects

FLEXIBLE RESPONSE

The flexible response doctrine stipulates that a state or alliance will meet any level of aggression with equivalent conventional or nuclear force and will increase the level of force, if necessary, to end the conflict. The doctrine originally emerged as a North Atlantic Treaty Organization (NATO) response to the Soviet Union's development of nuclear weapons capabilities, which called into question NATO's "massive-retaliation" strategy. Flexible response was adopted as the military strategy of NATO in 1967. Since the end of the Cold War, the doctrine has been modified by two new NATO "strategic concepts," but not formally replaced.

History and Background

NATO's first nuclear strategy, approved as Military Committee (MC) 48 in December 1954, threatened massive retaliation against the Soviet Union should it attack a member of the alliance (*see* Massive Retaliation). This heavy reliance on the nuclear threat was driven by the U.S. attempt to save money on defense and the failure of European allies to meet their non–nuclear force goals. It did not sufficiently anticipate the implications of future Soviet nuclear force deployments. The Soviet Union had successfully tested an atomic device in 1949 and a hydrogen bomb in 1953. But when MC 48 was approved, the Soviet Union had only limited means for delivering its few weapons on Western targets and virtually no means for threatening American territory. The launch of the Sputnik satellite in 1957 demonstrated the progress the Soviet Union had made in a very few years toward developing its own strategic nuclear weapons delivery systems and suggested that it would soon be capable of holding European *and* American cities hostage to a nuclear threat. This called into question the credibility of massive retaliation as the basis of NATO strategy.

The NATO allies struggled from the mid-1950s with attempts to adjust NATO's strategy and force posture to the evolving strategic environment. From the U.S. perspective, the steady growth of Soviet nuclear capabilities clearly necessitated a more flexible set of guidelines for the use of nuclear weapons. It was no longer credible simply to threaten attacks on the Soviet heartland with nuclear weapons in response to an attack on Western Europe. The American heartland had become vulnerable to a response in kind. The need for change was signaled by U.S. Secretary of Defense Robert McNamara in 1962. Such a momentous change in nuclear strategy, however, met with skepticism in Western Europe, largely from fear that the credibility of the nuclear guarantee would be destroyed by a strategy that foresaw the possibility of limited or controlled nuclear exchanges.

NATO's adoption of the doctrine of flexible response in 1967 followed several wrenching years of discussion and debate among the allies. The doctrine attempted to accommodate the American desire for more flexible nuclear options and European concerns about the credibility of the U.S. nuclear deterrent for Western Europe. Under the doctrine, Chicago might not be put at risk in the early stages of a conflict, but the possibility of escalation supposedly "coupled" the fate of Chicago to that of Paris, Hamburg, or London. The new nuclear doctrine did not reconcile American and European differences on nuclear strategy, but it did provide a formula that was sufficiently ambiguous to achieve political credibility on both sides of the Atlantic (*see* Coupling; Credibility; Deterrence; Escalation).

With the advent of flexible response and the development of limited nuclear options, the certainty implied by massive retaliation was replaced by the elusive goal of "escalation control." That NATO advantage was countered in the 1970s by Soviet nuclear force improvements, including deployment of the SS-20, a mobile, accurate missile system capable of carrying three independently targetable warheads on each missile.

In December 1979, led by U.S. President Jimmy Carter, the NATO allies decided on a dual-track approach: to modernize their theater nuclear forces to ensure the continued viability of the flexible-response doctrine while seeking to negotiate limits on such forces with the Soviet Union. The decision came in spite of growing public opposition to new missile deployments in several West European countries.

After defeating President Carter for the presidency, Ronald Reagan on November 18, 1981, called for the total elimination of all Soviet intermediate-range nuclear weapons in return for cancellation of NATO deployment plans. The initial Soviet response was negative. Tough negotiations stretched out over several years, until Soviet President Mikhail Gorbachev, judging that the Soviet Union could not afford to engage in an open-ended arms competition with the United States, decided to cut a deal.

On December 8, 1987, the United States and the Soviet Union signed the Intermediate-Range Nuclear Forces (INF) Treaty, which was designed to eliminate two categories of intermediate-range nuclear missiles: long-range and short-range INF. The treaty's terms were being implemented when the

Cold War came to an abrupt end with the breakup of the Warsaw Pact and the collapse of the Soviet Union. At the end of the Cold War, the United States initiated sweeping unilateral reductions in U.S. tactical nuclear weapons in Europe and elsewhere (*see* Cold War; Intermediate-Range Nuclear Forces [INF] Treaty).

Current Status

NATO twice revised its strategic plan in the 1990s, on both occasions passing up the opportunity to replace flexible response with a new strategy but substantially diminishing the role of nuclear weapons. In 1999, the allies stated that nuclear weapons continued to play an "indispensable" but largely political role in NATO strategy "to preserve peace and prevent coercion and any kind of war."

NATO has not directly linked its flexible-response doctrine, its nuclear weapons capabilities, or the concept of deterrence to the new problems of terrorism and the potential use of weapons of mass destruction by rogue states.

—Stanley R. Sloan

See also: Deterrence; North Atlantic Treaty Organization; Second Strike

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THE FOOTBALL

The "football," also known as the Presidential Emergency Satchel, contains the President's Nuclear Decision Handbook. It also includes the Single Integrated Operational Plan (SIOP), a list of classified bunkers for the president to go to in case of an emergency, and a communications packet that includes the authentication codes for the president to authorize the use of nuclear weapons through a secure satellite communications (SATCOM) radio. The football is carried by a military officer from one of the armed services who is always in the general vicinity of the president.

The official name of the football is classified. The nickname stems from the first SIOP, known by the code name "Dropkick" and initiated during the Dwight D. Eisenhower administration. The John F. Kennedy administration established the use of a briefcase to carry the SIOP and associated communications equipment in response to the Cuban missile crisis. The football established a direct command and control link from the president to the U.S. Nuclear Command.

The football is a black leather Zero-Halliburton brand briefcase with approximate dimensions of 18 by 15 by 10 inches. An inner titanium lining protects the contents from damage. The requirement for the football to be in close proximity to the president may change in the future; in fact, one proposal for downgrading the U.S. nuclear weapons posture is to distance the football from the president.

—Don Gillich

See also: Single Integrated Operational Plan

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FORWARD-BASED SYSTEMS

Forward-based systems (FBS) are nuclear delivery vehicles located outside one's own country but close to the adversary's territory, thus shortening the distance a weapon has to travel to strike an adversary. The Soviet Union was always concerned about the short warning time it would get from weapons launched at it from Western Europe. It was this very concern that presented one of the chief obstacles during the Strategic Arms Limitation Talks (SALT I) in 1969 and during SALT II in 1977. In an attempt to delineate what the SALT I Treaty would cover, the Soviets argued that any system that was capable of reaching the territory of the other side was strategic and hence subject to the treaty limits being negotiated. This language would have meant that U.S. fighter bombers and carrier-based attack aircraft would have been included, but Soviet intermediate-range ballistic missiles aimed at Western Europe would have been excluded. U.S. negotiators disagreed with the Soviet position, and the issue was put aside for a future arms control treaty. West European governments closely watched the U.S. position, fearing that the United States might bargain away its European-based nuclear assets, leaving Europe vulnerable to Soviet nuclear blackmail, given Soviet superiority in intermediate-range missiles. This issue would reemerge during the Soviet SS-20 and NATO dual-track decisions in 1979 (*see* Strategic Arms Limitation Talks [SALT I and SALT II]).

Washington believed that the Soviet position on forward-based systems was unacceptable and countered that its nuclear-capable aircraft and battlefield systems in Europe were there primarily for the defense of Europe and not for strategic missions against Soviet territory. In the SALT II negotiations, forward-based systems were dropped from consideration again when the Soviets refused to cut back on their heavy SS-18 intercontinental ballistic missile (ICBM) force. Since the early 1950s, the Soviets had maintained a potent offensive posture through the deployment of long-range theater nuclear forces (LRTNFs) in the western half of the Soviet Union. Made up chiefly of medium-range and intermediate-range ballistic missiles (MRBMs and IRBMs) and medium bombers, this Soviet force provided the capability to obliterate within a few minutes the entire fixed North Atlantic Treaty Organization (NATO) nuclear infrastructure. Likely targets included airfields, fixed defense and missile sites, nuclear storage depots, and all nonmobile support facilities.

The United States never attempted to match the Soviet effort in LRTNFs, preferring to rely on strategic nuclear systems, especially the U.S. submarine-launched ballistic missile (SLBM) force, which had a proportion of its targeting dictated by NATO requirements. U.S. land-based systems in Europe (chiefly tactical aircraft such as the F-4 and F-111) had both the nuclear weapons and the potential range needed to attack the U.S.S.R. Whether U.S. weapon systems had or did not have such a role in U.S. nuclear attack plans would not make any difference to a Soviet planner. The Soviets would have had to base their defense preparations on the assumption that U.S. FBS did have such a role and would respond accordingly. Based on this sort of logic, it is easy to understand why the Soviet Union maintained very large numbers of LRTNF systems—some 500 S-4 MRBMs, 100 SS-5 IRBMs, and several hundred medium bombers—for more than two decades. The flight times of those Soviet missiles from their silos to NATO airfields was about ten minutes, so even tactical warning of Soviet missile launch would not greatly increase the survivability of U.S. nuclear-equipped tactical aircraft.

With NATO-based systems and Soviet LRTNFs not subject to any superpower arms control treaty, a wave of modernization of these forces began in the 1970s. The Soviet Union retired its SS-4/5 missiles and replaced them with mobile SS-20s armed with multiple independently targetable reentry vehicles (MIRVs). In addition, Backfire TU-22M bombers were deployed that were capable of reaching most targets in Western Europe. Because Europe, and especially West Germany, feared decoupling from the U.S. strategic nuclear arsenal, NATO's theater nuclear forces were modernized with ground-launched cruise missiles (GLCMs) and the Pershing II mobile missile. Prior to deployment, superpower talks on intermediate-range nuclear forces (INF)—part of the so-called "dual-track" approach to NATO INF force modernization—began in Geneva. Both short-range and medium-range systems were included in the INF talks, which reached an impasse until 1987, when the Soviets accepted the opening U.S. proposal in the negotiations and agreed to a treaty banning intermediate nuclear forces.

—*Gilles Van Nederveen*

See also: Coupling; Intermediate-Range Nuclear Forces Treaty; North Atlantic Treaty Organization

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FRACTIONAL ORBITAL BOMBARDMENT SYSTEM (FOBS)

A fractional orbital bombardment system (FOBS) is an orbital nuclear weapons delivery system that inserts a payload into an orbital trajectory from which a reentry vehicle (RV) is deorbited. The Soviet Union attempted twenty-four FOBS test launches between 1965 and 1971 and deployed the system operationally from 1969 to 1983. FOBS are now prohibited under the Strategic Arms Reduction Treaty (START I) of 1991.

The earliest concrete proposal for this type of system originated from Soviet Chief Designer Sergey P. Korolev, who began preliminary work on the so-called Global Missile 1 (GR-1) in 1960. For Korolev, the GR-1 was part of the plan to develop a booster for the Soviet manned lunar effort. By 1962–1963, the U.S.S.R. had at least three major orbital weapons projects: the GR-1, a second FOBS project headed by General Designer Vladimir N. Chelomey, and a third by Mikhail K. Yangel's design bureau. In early 1965, prior to full testing of any system, the Strategic Rocket Forces conducted a comparative analysis and selected the Yangel option. After the twentieth test launch attempt, in August 1969 the first battalion of FOBS (R-36-O missiles) was put on combat duty at Tyuratam, located in Kazakhstan. In 1982, the U.S.S.R. began to dismantle the R-36-O, and the last missile was removed from duty in February 1983. Estimates on the yield of the FOBS warhead vary from between 2 and 20 megatons, and it was assessed to be able to hit within 3 to 5 kilometers of its intended target.

The apparent purpose of the FOBS was to provide the U.S.S.R. with more attack planning flexibility and options. The system could, for example, be used to strike the United States from the south, the direction with the fewest strategic early warning sensors. Secretary of Defense Robert S. McNamara publicly announced the existence of the system in November 1967 but attempted to downplay its significance, denying that it posed a major new strategic threat to the United States or violated the 1967 Outer Space Treaty, since the nuclear payloads were not in sustained orbit.

—*Peter Hays*

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FRATRICIDE

The term "fratricide" often refers to "friendly fire" incidents in which troops accidentally kill or wound their comrades instead of the enemy. In nuclear war planning, it is used to refer to the inadvertent destruction of nuclear warheads or delivery systems by other warheads and delivery systems that are part of the same attack.

When a nuclear weapon detonates, it creates blast, extreme atmospheric disturbance, electromagnetic pulse, and possibly enormous debris in the atmosphere (*see* Nuclear Weapons Effects). Incoming delivery systems or reentry vehicles that encounter these weapons effects can be destroyed, damaged, or knocked off course, leading to fratricide. Estimating fratricidal effects is extraordinarily difficult because it depends on the nature and severity of the effects encountered and the ability of the incoming weapon or delivery system to withstand these effects. To be safe, however, U.S. and Soviet nuclear war planners literally spent years "deconflicting" nuclear war plans to prevent fratricide while developing complex "walking barrages" to make sure that incoming warheads and delivery systems avoided the effects created by nearby detonations (in space and time).

Fratricide effects conspired to reduce confidence in any effort to launch a first strike to disarm an opponent. Since a massive and complex counterforce attack had never been undertaken, planners could never be sure of the extent or the true nature of the fratricide effects that would be produced by the detonation of thousands of nuclear weapons in relatively confined areas over a short period of time. The "dense pack" deployment scheme for land-based missiles developed in the late 1970s actually capitalized on the fratricide effect (*see* Dense Pack). Many believed that it would be difficult to destroy all missiles deployed in dense pack simultaneously because multiple nearby detonations would result in warhead fratricide.

—*James J. Wirtz*

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FREEZE

See Disarmament

FRENCH NUCLEAR FORCES AND DOCTRINE

France has pursued its own nuclear weapons programs and policies since the early days of the nuclear age. The instability of the Fourth Republic after World War II and a shortage of financial resources slowed French nuclear research, which lagged behind Soviet and American weapons programs. Gradually, however, France developed its nuclear weapons infrastructure and delivery systems.

History and Background

In October 1945, only two months after a nuclear weapon destroyed Hiroshima (*see* Hiroshima; Nagasaki), General Charles de Gaulle, as president of the Provisional Government, set up the Commissariat à l'Energie Atomique (French Atomic Energy Commission) to undertake research related to the use of atomic energy in the fields of science, industry, and national defense. In late 1954, the French government launched a secret program to develop a nuclear weapon. In April 1958, a ministerial top-secret order was given to prepare for the first series of atomic tests, which were to take place in early 1960.

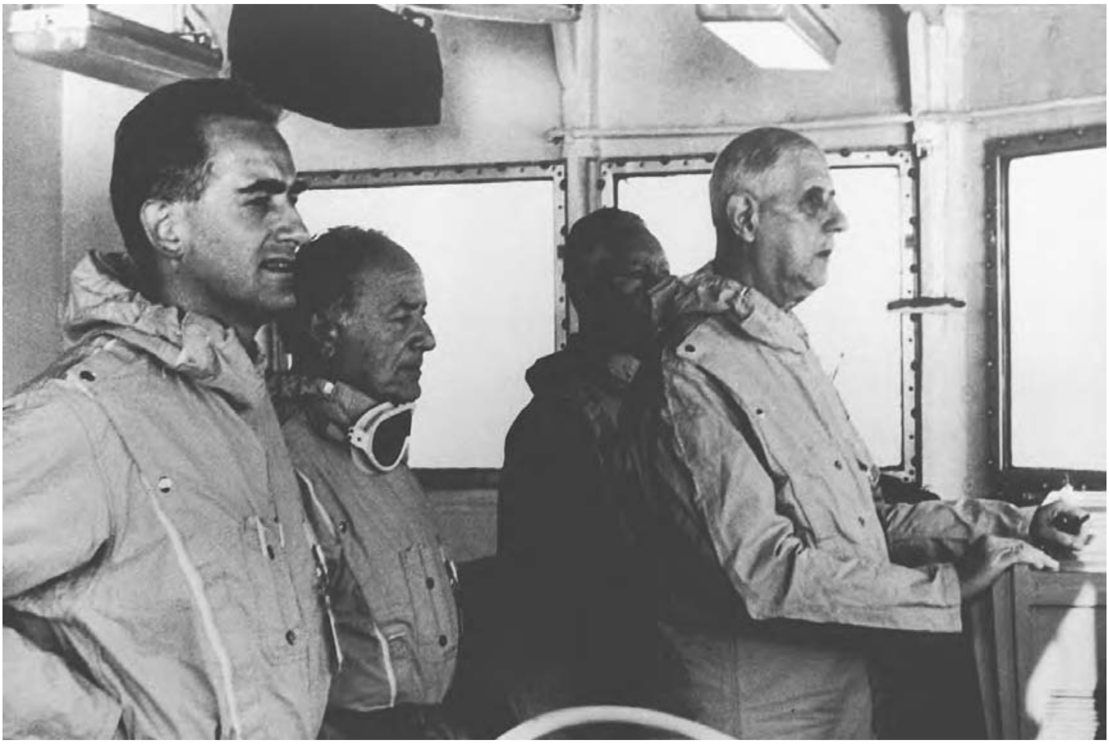
The French decision to acquire nuclear weapons was influenced by several factors. A nuclear arsenal was seen as a way to promote France's position as a great power and to reduce its reliance on the U.S. nuclear deterrent, thereby bolstering its diplomatic and military leverage with its allies and adversaries. Dismissing the North Atlantic Treaty Organization (NATO) concept of integrated forces, de Gaulle established an arsenal capable of acting on behalf of French interests. His aims for the *Force de Frappe* (or "Strike Force") were the restoration of French grandeur, the reunification of Europe under French leadership, and the subordination of West Germany to French leadership in Europe. Ultimately, a credible French nuclear arsenal would make possible an independent role for Europe in world affairs.

General de Gaulle continued to support the construction of an independent French nuclear arsenal throughout the 1960s. The *Force de Frappe* became a military priority for France, and several initiatives were launched simultaneously to make the French nuclear program a reality. An industrial complex was constructed that would enable France to manufacture highly enriched uranium (the only fissile material available to France had been plutonium) (*see* Highly Enriched Uranium [HEU]; Plutonium; Uranium). Mirage IV strategic bombers entered production and would eventually provide one arm of the nascent French nuclear Triad. A land-based prototype of a nuclear submarine power plant was put into operation as the initial step in building a new generation of French nuclear-powered submarines to be equipped with nuclear-armed ballistic missiles. The French also began work on an intermediate-range ballistic missile intended to hold at risk targets well within the borders of the Soviet Union.

In February 1960, the French program produced its first French nuclear device. A plutonium fission device, when tested at Reggane in the Algerian Sahara Desert it had a yield of about 65 kilotons and was three times more powerful than the Trinity device tested by the United States in 1945 (*see* Fission Weapons; Trinity Site). De Gaulle had rejected the moratorium on atmospheric testing proposed by the United States and the United Kingdom, and in a stand that outraged environmentalists worldwide, France refused in 1963 to sign the Limited Test Ban Treaty banning atmospheric tests. Testing continued as weapons and test devices were mounted on barges or suspended from balloons at France's Pacific Testing Center in Polynesia. In August 1968, following delays in the uranium isotope-separation process under way at a nuclear complex in Pierrelatte, the French detonated their first fusion device (*see* Fusion; Limited Test Ban Treaty; Thermonuclear Bomb).

General de Gaulle closely monitored the construction of France's emerging nuclear arsenal. In July 1960, the minister for the armed forces presented to Parliament a four-year plan to construct Mirage IV bombers and a nuclear-powered ballistic missile submarine (SSBN) and called for more research into thermonuclear weapons. The first Mirage IV squadron became operational in October 1964 as part of the new nuclear bomber force that now included Boeing C-135F air-to-air refueling aircraft sold to France by the U.S. government. The tankers greatly increased the range of the Mirage IV, thereby increasing the ability of the Mirage to penetrate Soviet airspace by adopting low level or circuitous flight profiles that increased the survivability of the Mirages. Initially, the French military chose the Mirage IV bomber as its primary nuclear delivery system for the *Force de Frappe*. In 1967, the *Force de Frappe* became operational with sixty-two aircraft, each capable of delivering a 60-kiloton nuclear bomb.

To save time and money, de Gaulle incorporated U.S.-supplied enriched uranium in the development of the nuclear power plant for France's new submarine fleet. A second military budget act covering the period 1966–1970 financed the construction of two nuclear submarines and strategic ballistic surface-to-surface missiles buried in silos on the Plateau d'Albion in Provence. Both forces became operational in 1971. De Gaulle also decided, in



President Charles de Gaulle observes a French nuclear test in Polynesia, 1966. (Corbis Sygma)

1963, that France, like the United States, should procure tactical nuclear weapons to be deployed on Mirage III and Jaguar aircraft and Pluton tactical nuclear missile launchers forward-deployed in West Germany.

Political Rationale for the Force de Frappe

By 1967, expenditures on the nuclear arsenal peaked at about 50 percent of France's defense capital expenditures. This proportion decreased steadily during the following years. De Gaulle's nuclear objectives were essentially political: to restore France's "greatness" by making the French directly and fully responsible for their own defense. The same considerations prompted him to refuse all proposals to cooperate with NATO in its nuclear war plans: He refused to have medium-range missiles installed on French soil, and he rejected French participation in a NATO multilateral nuclear force. In 1958, he also breached a secret protocol negotiated under the Fourth Republic to begin nuclear cooperation with the Germans and Italians.

The general's overriding focus on political ends did not mean, however, that he took no interest in the strategy of deterrence as it applied to France: deterrence of the strong by the weak. What really counted for him was the determination of the "deciding party." He vested sole power to decide the use of France's nuclear arsenal in the Office of the President of the Republic. French doctrine reflects a concept of "nonemployment," that is, there is no question of using nuclear weapons in conflicts that do not threaten vital interests. Contrary to the NATO doctrine of flexible response, French doctrine did not incorporate the threat of gradual nuclear escalation to back up conventional deterrence. French nuclear doctrine is instead motivated by the effort to guarantee that France can deter an adversary by inflicting damage that is out of proportion to any benefits that could be achieved by attacking France. The French posture was one of immediate and massive retaliation once French territory was threatened.

The credibility of the French nuclear deterrent was of course in the mind of the beholder, but after about 1969 doubts emerged about the ability to make good on these deterrent threats. The ability of the fixed-site ballistic missiles to escape destruction if the Soviets struck first was suspect, and the ability of the Mirage IV to penetrate Soviet air defenses was questionable. French planners recognized these shortcomings and worked diligently to deploy a submarine-based deterrent force. Financial constraints and difficulties in development resulted in delays. In 1971, the first nuclear-armed submarine, *Le Redoutable,* became operational (*see* Credibility; Deterrence; Escalation; Flexible Response; Massive Retaliation).

French Forces and Doctrine after de Gaulle

A defense doctrine review ordered by President Giscard d'Estaing deemphasized the role of nuclear weapons in French defense strategy, although French scientists continued work on the next generation of nuclear weapons. Neutron warheads were developed, but never deployed, for the Hades short-range surface-to-surface missile system. Work also progressed on penetration aids for French ballistic missiles.

During the Euro-missile debate of the early 1980s, which was prompted by NATO's decision to upgrade its intermediate-range nuclear forces (INF), French and British officials refused to include their nuclear forces in the superpower INF talks in Geneva. The French government supported NATO's dual-track (negotiating while deploying) decision and its upgrades to its intermediate-range nuclear delivery systems. President François Mitterrand, who was wary of neutralist trends that had emerged in West Germany, all but endorsed the West German government's center-liberal proposals in the 1983 election to deploy both Pershing and ground-launched cruise missiles.

In the aftermath of the Cold War, French nuclear doctrine began to adjust to new strategic realities. The Mirage IV was retired, the missile field in the Plateau d'Albion was dismantled, and France settled on a dyad of systems: SSBNs and the Mirage 2000 and Super Entendard equipped with standoff cruise missiles. The Rafale will take their place as it enters service in the French Air Force and French Navy. Along with downsizing their nuclear forces, French officials have placed greater emphasis on developing improved space-based reconnaissance and communications capabilities. French nuclear weapons policy and doctrine have remained remarkably stable and consistent over the past thirty years through periods of government under right-wing, centrist, and socialist parties.

—Gilles Van Nederveen

See also: Strategic Forces; Submarine-Launched Ballistic Missiles; Submarines, Nuclear-Powered Ballistic Missile; Tous Asimuts

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FUEL FABRICATION

Fuel fabrication is part of the nuclear fuel cycle, the process of converting uranium ore into the fissile isotope uranium 235 (U-235), which is used to generate electricity. Uranium ore is mined, milled, and converted into the gas uranium hexafluoride (UF_6) so that it can be enriched and fabricated into fuel. Different types of reactors require different types of nuclear fuel.

Light-water reactors can use two types of fuel. Some require low enriched uranium (LEU). To fabricate LEU, UF_6 is chemically processed to uranium dioxide powder, pressed into pellets, and loaded into

Zircaloy tubes. These fuel rods form the fuel assemblies that power the reactor. Plutonium and uranium, recovered by reprocessing spent fuel from light-water reactors, may be reused as fuel. Light-water reactors also may be fueled with mixed oxide, a combination of uranium dioxide and plutonium oxide. This second fuel-fabrication process offers an important way to render highly enriched uranium (HEU) contained in retired nuclear weapons less dangerous. The U.S. Department of Energy "downblends" HEU taken from retired Russian and U.S. nuclear weapons with other uranium to create LEU reactor fuel.

Small reactors used for research, testing, and training that do not generate electrical power sometimes use specialized "plate" fuels. Plate-type fuel consists of several layers of various uranium mixtures that are packed into aluminum plates. Although HEU can be used to fuel these small reactors, proliferation concerns have discouraged the use of HEU in specialized reactor applications.

—James J. Wirtz

See also: Highly Enriched Uranium; Isotopes; Low Enriched Uranium; Nuclear Fuel Cycle; Plutonium; Reactor Operations; Uranium

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FUSION

Fusion is the process by which one heavier nucleus is produced from two lighter nuclei. According to Albert Einstein's special theory of relativity, mass and energy are equivalent. In fusion, some of the mass of the two lighter nuclei is converted to energy. Fusion reactions power the sun and stars and are responsible for the enormous release of energy from a hydrogen bomb. The use of nuclear fusion reactions as a controlled source of energy is feasible, but there are significant engineering problems still to overcome.

The search for a safe, efficient, and plentiful source of energy has been ongoing since the very dawn of mankind. Our current energy of choice, obtained from fossil fuels, is finite. The promise of fission power as an energy source has faded somewhat owing to public concerns over nuclear waste disposal and the dangers of accidental radiation release. Fusion energy holds the promise of providing an inexhaustible energy supply that is safe, reliable, efficient, economical, and environmentally friendly. This technology, however, is not yet mature. Significant problems still must be overcome.

The nucleus of an atom is held together by the strong force. This short-range attractive force acts as a sort of nuclear glue, counteracting the repulsive electrical force between positively charged protons. For fusion to occur, the two light nuclei must be brought into very close proximity. Since each nucleus has a net positive charge, the nuclei must overcome a very strong repulsive force, the "Coulomb barrier," before they can be brought close enough together to fuse. One way to overcome the Coulomb barrier is to raise the kinetic energy of the particles by increasing their temperature. A high density of light nuclei, along with a long confinement time, will ensure a high probability of collisions and the fusion rate necessary to produce useful amounts of energy. In stars these conditions exist naturally. To harness fusion power in a reactor, scientists and engineers must, in essence, re-create the conditions that exist in a star.

Owing to their availability and their interaction probability, the light elements of choice for producing usable energy in a fusion reactor are deuterium and tritium (D-T) in combination (*see* Deuterium; Tritium). Deuterium can be extracted from sea water, where 1 in 6,500 hydrogen atoms is deuterium. D_2O is known as "heavy water" (*see* Heavy Water). Tritium can be bred from lithium, which is abundant in the Earth's crust. Thus, the fuel for the fusion reaction is considered inexhaustible and accessible.

As the temperature of the D-T mix is raised, a gas-like mixture of electrons and ions, called a "plasma," is established. The plasma must be heated to nearly 100 million degrees Celsius to give the D-T particles sufficient kinetic energy to overcome the Coulomb barrier. Since the electrons and ions have electric charge, the plasma can, in principle, be confined by a magnetic field. The challenge is to confine the plasma in sufficient density for a long enough time for the reactions to take place, and for the energy to be extracted. One method for containing the high-temperature plasma is through use of a magnetic field that is toroidal, or doughnut-shaped. In the toroid, the plasma forms a continuous circuit and the particles are forced to follow a path along the magnetic field lines. The Russian-designed *tokamak* (a toroidal confinement machine) has been the most successful confinement approach. No material can withstand the high temperatures of a fusion plasma. Fusion plasmas cool quickly if they touch the wall of the vacuum chamber, however. The tokamak uses strong externally applied magnetic fields to contain the plasma and maintain separation from the chamber walls. Among many engineering challenges to be solved before controlled fusion reactions become commonplace is the development of materials that are resistant to high-energy particle bombardment, thermal stresses, and magnetic forces.

As a cost-effective way to further worldwide fusion research, and to demonstrate the essential technologies necessary for the eventual commercial production of fusion power, the international community is scheduled, in 2006, to begin building the International Thermonuclear Experimental Reactor (ITER). The ITER is a power reactor–scale fusion research project and is to be completed in 2014. The United States was a member of the original planning team (with Canada, the European Union, Japan, and Russia) but withdrew from the project in 1999 because of the ITER's high projected cost. Both the United States and China have recently rejoined the negotiations for the construction and operation of the ITER. In the United States, the National Ignition Facility at Lawrence Livermore National Laboratory is working to attain fusion ignition in the laboratory. This will provide the basis for future decisions about fusion's potential as a long-term energy source.

—*Brian Moretti*

See also: Deuterium; Reactor Operations

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FUSION WEAPONS

See Hydrogen Bomb; Implosion Devices; Thermonuclear Bomb

G

G8 GLOBAL PARTNERSHIP PROGRAM

The Global Partnership Against the Spread of Weapons and Materials of Mass Destruction is an initiative of the Group of Eight, a forum for eight industrialized countries (the G8, which includes the United States, the United Kingdom, Canada, France, Germany, Italy, Japan, and Russia). The Global Partnership Program is aimed at preventing terrorists from obtaining weapons of mass destruction by denying them access to material and personnel, in Russia, that could be used for that purpose.

At the 2002 G8 Summit in Kananaskis, Canada, the G8 countries committed to raise up to $20 billion over ten years to fund nonproliferation projects, primarily in Russia. Under the "10 plus 10 over 10" plan, the United States is to provide $10 billion, with the other half to come from the remaining G8 members over a ten-year period. The European Union, Norway, Sweden, Switzerland, Finland, the Netherlands, and Poland agreed to support the plan as donors in 2003, as did Australia, Belgium, the Czech Republic, Denmark, Ireland, the Republic of Korea, and New Zealand in 2004. The program focuses on four priority areas: destroying chemical weapons stockpiles, dismantling decommissioned nuclear submarines, securing nuclear and radiological materials, and finding civilian employment for former weapons scientists. As part of the initiative, G8 leaders established nonproliferation principles, guidelines for projects, and a Senior Officials Group to coordinate partnership programs. The partnership incorporates preexisting programs as well as new initiatives. At the June 2004 Sea Island, Georgia, summit, G8 leaders considered and supported in principle expanding the program to recipient countries other than Russia, including Ukraine and other former Soviet states, Iraq, Libya, and Albania.

Results to date have been mixed, with destruction of chemical stockpiles proceeding slowly and pledges, as of early 2004, just short of $20 billion. Disputes over liability protection, tax exemptions, and access to sensitive sites have hindered projects. The partnership, however, establishes a framework for increased cooperation to deal with the threat of terrorist acquisition of weapons of mass destruction.

—Michael Lipson

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GAITHER COMMISSION REPORT

In November 1957, a committee of security experts and consultants chaired by H. Rowan Gaither, Jr., an attorney and RAND Corporation board member, submitted a secret report to President Dwight D. Eisenhower recommending a sharp increase in U.S. offensive and defensive capabilities to combat Soviet military and diplomatic initiatives. Eisenhower had organized the committee in response to growing debate on the need for civil defense measures. During its deliberations, the committee vastly expanded the scope of the study to include an overview of strategic policy. The committee consisted of twenty scientific, industrial, and military leaders as well as about seventy consultants. The final report, however, probably best reflected the views of two members of the group: Colonel

George A. Lincoln, who had coordinated strategic planning during World War II, and Paul H. Nitze, who had served on the Policy Planning Staff in the State Department under President Harry S. Truman and was a sharp critic of Eisenhower's New Look strategy of massive retaliation.

The Gaither Commission Report stressed an emerging Soviet threat, including an operational Soviet intercontinental ballistic missile. It called for increasing the U.S. missile arsenal, reducing bomber vulnerability, enhancing the ability to fight limited wars, implementing a nationwide system of civil-defense shelters, and reorganizing the military to address emerging threats. The report estimated these goals would require a $44 billion increase in defense spending over four years.

The report's impact has been debated. Eisenhower and others rejected some of its assumptions on Soviet capabilities. The president also was opposed to massive budget increases. The United States did, however, launch a major buildup of its strategic nuclear forces in the late 1950s and 1960s. Other factors, such as a gradual loss of faith in massive retaliation and the Soviet launch of Sputnik just prior to the report's completion, make it difficult to assess whether the report changed views or only reinforced perceptions that would have led to a U.S. nuclear buildup in any case. Some scholars argue that the report was central to shifts in planning under Eisenhower and even more influential in the incoming John F. Kennedy administration. President Kennedy read the report and brought some of its authors into his administration. The report's critical assessment of the efficacy of basing U.S. defense policy on a deterrence strategy helped lend weight to early arms control efforts.

—*James J. Dietrich*

See also: Cold War; Deterrence; Massive Retaliation

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GAME THEORY

Game theory is useful in conducting systematic analyses of the interdependent effects of actors' decisions in strategic planning and wartime responses. It can help theorists to understand the potential for use of weapons of mass destruction (WMD) and related topics such as mutual assured destruction, deterrence, extended deterrence, and credible threats. In game theory, two (or more) rational players simultaneously choose actions that maximize their expected payoffs. The particular payoffs players receive depend on their own choices as well as those of the other players. Recognizing this interdependence, players anticipate the behavior of the other players when choosing their actions. Game theorists predict behavior by determining the game's equilibrium outcomes, that is, the joint outcomes where players cannot unilaterally improve their payoffs. Analyzed through mathematical deduction, game theory models identify the implications of a particular set of assumptions. Games are theoretical, not empirical, but some can be tested using statistical, qualitative, or computer-simulation analyses. Game theoretic arguments are precise, necessarily logical (that is, the arguments flow from the assumptions), and sometimes result in counterintuitive or surprising implications.

Games used to motivate WMD topics commonly involve two players choosing between two choices, such as whether or not to increase funding for nuclear weapons development (Schelling; for problems with this type of theorizing, see Wagner). The most famous game is the Prisoner's Dilemma, where two players are taken prisoner and given the choice of implicating their partner or remaining silent. This game is unusual in that regardless of the prisoners' anticipation of what their partner will do (talk or remain silent), they each have an incentive to talk. This situation represents a "dominant strategy," where a choice is superior regardless of one's expectations of the other players' actions (Morrow). When applied to nuclear deterrence during the Cold War, the Prisoner's Dilemma, for many theorists, represented the pressures that led to the race between the superpowers to arm themselves with larger and more sophisticated nuclear arsenals.

Game theory has a number of implications for studies of weapons of mass destruction. First, the value of an action is not intrinsic to that choice but also depends on what one expects others to do, since the payoff received is the result of the decisions of all the players. Conversely, in situations represented by games such as the Prisoner's Dilemma, there may be "dominant" strategies that represent superior choices regardless of an adversary's actions. However, efforts such as reputation building and repeat interaction may moderate these dominant-strategy situations and facilitate cooperation (Axelrod). Recent game theoretic treatments of deterrence focus on the information necessary for actors to *signal credible threats* (Powell). These models are sometimes known as "signaling games" and "games of limited or incomplete information," and although they can be quite complex mathematically they reflect a more realistic and interesting decision-making environment. Some studies show that players can gain a signaling advantage by appearing to eliminate their own ability to act. Thus, states in some deterrence situations might have incentives to create automatic processes for the use of their nuclear weapons (*see* Chicken, Game of). Finally, game theory illustrates the importance of thinking about the choices that players do not make—a concept called "off-the-equilibrium-path behavior." Analyses suggest that expectations about the consequences of unobserved choices influence the behavior that we do observe. Off-the-equilibrium-path behavior theories are especially effective at capturing the important difference in studies of deterrence between threatening to use weapons of mass destruction and actually using them, and the concept can also help to link arguments about selection effects (having weapons of mass destruction) and behavior (employing them).

—Scott Sigmund Gartner

See also: Credibility; Deterrence; Extended Deterrence; Mutual Assured Destruction

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GAMMA RAYS

See Radiation

GAS-GRAPHITE REACTORS

A gas-graphite reactor is a graphite-moderated, gas-cooled atomic reactor used for developing electrical power. Compared to other types of reactors, gas-graphite reactors enjoy greater thermal efficiency (generally between 40 and 50 percent).

The first commercial nuclear power reactor to provide electricity was a Magnox-type gas-graphite reactor at Calder Hall in Cumbria, England, in 1956. The cladding material, which contains the natural uranium fuel, is a magnesium alloy called Magnox.

In the 1950s and 1960s, gas-graphite reactors were built in the United Kingdom, France, Italy, and Japan. The advanced gas reactor (AGR) was developed by the United Kingdom in 1964. The British built five AGR nuclear power plants in England and two in Scotland.

In 1967, the United States developed the high-temperature gas-cooled reactor (HTGR). Germany developed and built HTGRs in the 1980s. North Korea built three Magnox-type gas-graphite reactors in the mid-1980s to mid-1990s. South Africa developed the pebble-bed modular reactor (PBMR) design in the 1990s.

The coolant used in gas-graphite reactors is usually carbon dioxide (CO_2). CO_2 is used because it has a low absorption cross-section for thermal neutrons and does not react with the moderator or the fuel at temperatures below 540 degrees Celsius. The AGR is graphite moderated and CO_2-gas cooled. The fuel is slightly enriched uranium in stainless steel cladding.

HTGRs are helium-cooled reactors fueled with a mixture of thorium and highly enriched uranium. PBMRs are helium-cooled reactors that use graphite-coated, enriched-uranium fuel spheres.

South Africa is constructing a PBMR-type reactor that is scheduled to begin operation in 2007. The United States and Japan are conducting research into PBMR technology.

—Don Gillich

See also: Enrichment; Graphite; Highly Enriched Uranium; Reactor Operations; Uranium

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GEIGER COUNTER

The Geiger counter, also known as a Geiger-Mueller counter, is an instrument used to detect and measure all three types of radioactivity (alpha, beta, and gamma radiation). It was invented by Hans Geiger and Ernest Rutherford in Manchester, England, in 1911 and later improved by Geiger and Walther Mueller in 1928.

Radioactive materials emit particles called "fast electrons" (electrons that have been accelerated to about a third of the speed of light) and "ions" (atoms that have gained or lost an electron). A Geiger counter usually consists of a gas-filled metal tube with a thin metal wire running through it. Each of these metal pieces serves as an electrode. The electrons and ions emitted by the radioactive material penetrate the tube and are attracted to electrons from the atoms of gas, thus "ionizing" the gas. Ionized gas conducts electricity, completing an electrical circuit between the two electrodes. The current created is amplified electronically to produce a series of clicks that alert the user to the presence of radiation. The amount of radiation present can be counted because every particle passing through the tube produces a separate pulse.

Geiger counters could quickly and easily be used to detect radiation emitted through the detonation of a radiological weapon, thus allowing the identification of harmful materials that otherwise could not be seen and warning of the presence and the level of danger to people in the area. Using a Geiger counter would be a quick way to determine the difference between a conventional explosion and a dirty bomb.

—Andrea Gabbitas

See also: Radiation

Reference

Lawrence Livermore National Laboratory website, http://www.lbl.gov/abc/.

GENEVA, SWITZERLAND

See Arms Control

GLOBAL PROTECTION AGAINST LIMITED STRIKES (GPALS)

Global Protection Against Limited Strikes (GPALS) was the George H. W. Bush administration's effort to reorient its ballistic missile defense program away from the threat of a massive Soviet attack and toward the threat posed by accidental and unauthorized missile launches and small attacks by Third World countries.

The end of the Cold War and the collapse of the Soviet Union reduced the likelihood of the United States suffering a massive nuclear attack. The 1991 Gulf War demonstrated that shorter-range missiles posed a threat to U.S. friends, allies, and forces abroad. In his 1991 State of the Union Address, President Bush announced that he had directed the Strategic Defense Initiative (SDI) program to focus on providing protection against limited ballistic missile strikes, whatever their source (*see* Strategic Defense Initiative [SDI]). Henceforth, ballistic missile defense would deal with future threats "to the United States, our forces overseas and to our friends and allies."

The ensuing concept, dubbed GPALS, was intended to defend against an accidental or unauthorized missile launch from Russia or a small volley of missiles launched from another country. The system's goal was to protect the United States against a strike of up to 200 warheads launched from anywhere in the world. It also put a greater emphasis on theater missile defense (TMD) (*see* Theater Missile Defense).

Three main components were to be included in GPALS: a ground-based TMD, a ground-based national missile defense (NMD), and a space-based global missile defense (GMD). NMD would include 750 ground-based interceptors (GBIs) deployed at six sites in the United States to defend against accidental and unauthorized strikes from any source. GMD would be composed of 1,000 space-based "Brilliant Pebbles" satellites to destroy missiles with ranges greater than a few hundred miles. TMD systems would be deployed to protect U.S. forces overseas, friends, and allies.

Spearheaded by Senators Sam Nunn (D–GA) and John Warner (R-VA), Congress passed the Missile Defense Act of 1991, which called for the deployment by 1996 of a 100-interceptor antiballistic missile site "as the initial step" toward the fielding of a nationwide defense. The Bush administration also pursued the possibility of using GPALS as the nucleus of a joint U.S.-Russian missile defense system (*see* Missile Defense).

After the William Clinton administration took office in 1993, it replaced GPALS with a ballistic missile defense architecture that emphasized NMD and TMD and deemphasized space-based defenses such as Brilliant Pebbles.

—*Tom Mahnken*

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GRAPHITE

Graphite is used as a moderator and reflector of neutrons in some nuclear reactors because of its low mass number, low absorption, and high scattering cross-sections. Even though it is not a metal, graphite is a good conductor of heat. It also is abundant in nature and inexpensive.

Enrico Fermi achieved the first nuclear chain reaction at Stagg Field Stadium, Chicago, on December 2, 1942, using a "pile" of natural uranium and approximately 400 tons of graphite as the moderator. Graphite also was used as the moderator for the Hanford "B" reactor in Hanford, Washington. Hanford "B" provided the plutonium for the implosion devices tested at the Trinity Site and dropped on Nagasaki, Japan, in 1945.

The RBMK-1000 type nuclear reactor at Chernobyl in the former Soviet Union was a graphite-moderated reactor. During the accident at Chernobyl on April 25–26, 1986, a rapid energy release from the fuel caused the graphite to ignite. The subsequent graphite fire destroyed the containment facility and spread radioactive contamination into the atmosphere and surrounding area (*see* Chernobyl).

Natural graphite is not pure enough to be used in nuclear reactors. Reactor-grade graphite is manufactured from a mixture of petroleum coke and coal tar pitch through a baking process. Reactor-grade graphite has a density of approximately 1.6 grams per cubic centimeter.

—*Don Gillich*

See also: Gas-Graphite Reactors; Hanford, Washington; Reactor Operations; Uranium

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GRAVITY BOMBS

A "gravity bomb," also known as a "dumb bomb," is an aircraft-delivered bomb that does not contain a guidance system but free-falls to its target. The United States carries a wide variety of gravity bombs in its arsenal (*see* Tactical Nuclear Weapons).

MK-80 series bombs are typically armed with the M904 nose and M905 tail fuses or the radar-proximity FMU-113 air-burst fuse. The MK-80s also can be fitted with a "ballute" parachute to retard the fall of the bomb. MK-80s can been used against a wide variety of targets, including artillery, vehicles, bunkers, missile sites, antiaircraft artillery sites, radars, and supply depots. There are many different sizes in the MK-80 series of bombs, which differ in terms of their weight and the size of the blast they produce. The MK-82 is a 500-pound bomb, the MK-83 is a 1,000-pound bomb, and the MK-84 is a 2,000-pound bomb.

Most cluster bombs used by the United States are gravity bombs. Cluster bombs open at a fixed height above a target area and then disperse dozens of small "bomblets," which are occasionally retarded by parachutes. These bomblets drop in a preplanned pattern into the target zone. Filled with explosives, they are usually scattered over hundreds of square meters and detonate individually. Typically, cluster bombs are used against "softer targets," namely personnel and equipment that lacks armor protection.

—*Abe Denmark*

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"Weapon Systems in Use by U.S.," available at http://www.fas.org/terrorism/str.

GROUND-LAUNCHED CRUISE MISSILES (GLCMs)

The ground-launched cruise missile (GLCM) is a mobile, highly accurate, land-attack, precision-guided combination of airframe and munition that flies to its target along a preprogrammed flight path. It can be armed with either nuclear or conventional weapons. A 1979 North Atlantic Treaty Organization (NATO) decision to deploy a new generation of theater nuclear forces, including GLCMs, exacerbated tension with the Warsaw Pact and led to a revival of the peace movement and a series of mass protests throughout Europe. By 1987, before the full deployment was carried out, the Intermediate-Range Nuclear Forces (INF) Treaty was signed by the United States and the Soviet Union, halting NATO INF modernization (*see* Intermediate-Range Nuclear Forces [INF] Treaty).

A ground-launched cruise missile being test fired from its camouflaged transporter-erector-launcher, 1985. (Tech. Sgt. Bill Thompson/Corbis)

With its 1979 decision to deploy 108 Pershing II ballistic missiles and 464 GLCMs to five NATO members, NATO aimed to replace the existing force of obsolete strike aircraft and Pershing I missiles with longer-range, more accurate weapons to restore the credibility of the long-range theater nuclear force and counter the deployment of Soviet SS-20 missiles.

GLCMs, like the sea-launched cruise missiles (SLCMs) and air-launched cruise missiles (ALCMs) initially deployed by the United States in the late 1970s, were subsonic, terrain-following aircraft designed to fly a preset course up to a range of 2,500 kilometers. They were deployed in groups of four on transporters with an ability to maneuver off-roads. Four transporters formed a flight of missiles. The planned deployment was to Italy, the United Kingdom, the Netherlands, and Belgium.

The system was eliminated under the INF Treaty. GLCM bases in Europe remain subject to inspection.

—*Andrew M. Dorman*

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GROUND ZERO

Ground zero is the epicenter of a nuclear explosion and the area of maximum damage produced by the heat and blast of a nuclear detonation. The areas referred to as "ground zero" at Hiroshima, Nagasaki, and the test areas at the Nevada Test Site designate exactly where nuclear explosions occurred. As a reference to the total destruction of the World Trade Center on September 11, 2001, rescue workers quickly dubbed the area where the Twin Towers stood as "ground zero," suggesting that the level of devastation resembled the aftermath of a nuclear attack (*see* Hiroshima; Nagasaki; Nevada Test Site).

In the aftermath of a nuclear detonation, destruction will radiate outward from ground zero as the surrounding area is struck by an initial blast wave and a secondary reflected wave. Objects that are in the path of the blast waves are susceptible to sharp and severe increases in atmospheric pressure and severe winds. Residual effects following a nuclear blast at ground zero include high levels of radiation (*see* Nuclear Weapons Effects; Radiation; Underground Testing).

Ground zero, or Designated Ground Zero (DGZ), is a term used by nuclear war planners to identify the exact aim point where a nuclear weapon is targeted. DGZs are selected to maximize damage to targets within the destructive range of the weapon. A key variable in varying the nuclear weapons effects surrounding the DGZ is the weapon's "height of burst," or the altitude at which the weapon detonates.

In an example of black humor, the central courtyard of the Pentagon in Washington, D.C., has a small snack bar in the middle sometimes referred to as the "Ground Zero Café."

—*Laura Fontaine and James J. Wirtz*

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GUN-TYPE DEVICES

A gun-type device creates a supercritical mass of fissionable material, uranium 235 (U-235), to produce a nuclear explosion. This technique involves the use of conventional propellants or explosives to drive a subcritical, fissionable projectile into a second subcritical, fissionable target to achieve a supercritical mass. The technique also can entail using more than two subcritical masses that are brought together rapidly to achieve a nuclear explosion.

The first nuclear weapon ever used in combat was the gun-type device "Little Boy," the bomb dropped by the United States on Hiroshima, Japan, on August 6, 1945 (*see* Hiroshima; Little Boy). Its explosive yield was approximately 15,000 tons of TNT. The gun-assembly method of attaining a supercritical mass was considered to be so infallible, and highly enriched uranium so valuable, that the Little Boy designers chose not to test the bomb prior to its use. In fact, the Little Boy weapon used the entire stockpile of highly enriched uranium in the United States at the time of its construction (*see* Highly Enriched Uranium [HEU]; Uranium).

Unlike the implosion technique for attaining a supercritical mass, the gun-assembly method is inefficient because it does not compress the fissionable material to achieve greater density (*see* Criticality and Critical Mass). Although it was an inefficient way to achieve nuclear fission, the United States used the gun-assembly method to develop special-purpose weapons, such as penetration weapons for subsurface detonations and early tactical nuclear weapons, including artillery-fired atomic projectiles (AFAPs). Because of the simplicity of the design, the gun-type device has been used by other countries and is the weapon of choice for emerging nuclear weapons states.

History and Background

After the discovery of fission in late 1938, there was much debate about the possibility of harnessing the energy of fission to make a nuclear weapon. Otto Frisch and Rudolf Peierls authored a memorandum in February 1940 that served as the impetus for the development of the gun-type device. In the Frisch-Peierls Memorandum, the authors discuss the possibility of constructing a "super bomb" using a "critical size" of pure U-235. They describe how to keep two (or more) subcritical pieces of uranium apart to avoid the possibility of premature detonation due to stray neutrons. They also discuss providing a mechanism to bring the two parts together rapidly to achieve a nuclear explosion. Frisch and Peierls were living in the United Kingdom at the time, and they submitted their manuscript through Mark Oliphant, the director of the physics department at the University of Birmingham, to Henry Tizard, the chairman of a scientific committee devoted to the defense of the UK.

In April 1940, Tizard formed a separate group, known as the MAUD Committee, to discuss the possibility of building a nuclear weapon. The MAUD Committee's final report, composed before the group disbanded in July 1941, concluded that nuclear weapons were feasible and that the development of this type of weapon could result in decisive victory in World War II. It also provided technical details about the amount of uranium necessary and the expected yield as well as cost estimates to build a nuclear weapon.

Based on the findings of the MAUD Report, President Franklin D. Roosevelt decided to expand support for a U.S. program to develop nuclear weapons. After a slow start, the U.S. nuclear bomb project was consolidated in September 1942 into the Manhattan Project, which was led by Major General Leslie Groves and Professor J. Robert Oppenheimer (*see* Manhattan Project). Groves and Oppenheimer created a laboratory at Los Alamos, New Mexico. As scientists arrived at Los Alamos, theoretical physicist Robert Serber gave a series of lectures designed to sum up the current knowledge of nuclear weapons design. As part of these lectures, Serber outlined the gun-assembly method of creating a supercritical mass of fissionable material through the use of a cylindrical projectile fired into a spherical target. These lectures were later published as the *Los Alamos Primer* (1992).

The original plan was to use the gun-assembly method to attain a supercritical mass for both uranium 235 and plutonium 239. The Los Alamos Ordnance Division under Navy Captain William Parsons was in charge of directing gun-type weapons research. Early research focused on developing a gun with a very high velocity, greater than 3,000 feet per second, to assemble a critical mass of plutonium. Plutonium has a high spontaneous fission rate, which means that a high muzzle velocity would be required to assemble a supercritical mass before the plutonium could predetonate, resulting in low or no nuclear yield.

In April 1944, Italian physicist and emigrant Emilio Segré, who was working on the Manhattan Project, measured the spontaneous fission rate of plutonium and found that it was much higher than previously thought owing to the existence of trace amounts plutonium 140, which contaminated the plutonium. As a result, the plutonium gun-type weapon was abandoned, and the implosion technique would be used to achieve a supercritical mass for a plutonium-based weapon. A crash program to develop the implosion device required a complete reorganization of effort in the Manhattan Project.

In August 1944, Navy Commander A. Francis Birch was given the responsibility of completing the uranium gun-type weapon dubbed Little Boy. Birch completed testing of the Little Boy gun tube using natural uranium. By May 1945, the design and testing of the weapon were complete; the only component missing was the highly enriched uranium core. In July 1945, approximately 60 kilograms of highly enriched uranium was fabricated into both target and projectile and the first gun-type weapon was ready for use.

After World War II, several designs of gun-type weapons were developed. The gun-type weapons Mark 8, 10, and 11 were developed as penetrating weapons to be used against armored, reinforced, or underground targets. Early gun-type AFAPs also were developed. The first AFAPs were the Mark 9 and Mark 19, which were 11-inch-diameter artillery shells. An 11-inch howitzer had to be designed and built to accommodate these new nuclear weapons, since the largest howitzer in the army at the time was only 8 inches in diameter. Another AFAP was the Mark 23, a 16-inch-diameter projectile designed for naval guns. By the mid-1950s, the Mark 33, a gun-type, 8-inch AFAP, had been designed and tested for the army's 8-inch howitzer.

Technical Details

Timing in a gun-type weapon, as with any nuclear weapon, is critical because it largely determines the amount of energy yield that can be achieved given a specific quantity of fissile material. Each generation of neutrons takes approximately 10 nanoseconds to generate once the supercritical chain reaction is started. The challenge is to create as many generations of neutrons as possible before the device explodes due to the heat and pressures produced by fission. To produce an appreciable yield, it is desirable to hold the supercritical chain reaction together for 50 to 100 generations, that is, 0.5 to 1 microseconds. Consequently, there are several basic components to a gun-type device that are necessary for its proper function in addition to the subcritical, fissionable target and projectile.

One basic component is a neutron initiator that must be present to provide a large number of initial neutrons to generate the explosive chain reaction at the precise time that the mass becomes supercritical. In the case of Little Boy, this initiator consisted of polonium and beryllium. When crushed together, polonium emits large numbers of alpha particles that are energetic enough to separate neutrons from the beryllium. This provides the first generation of neutrons as the supercritical mass begins the explosive chain reaction.

The supercritical mass is usually a sphere. A sphere is used because compared to all other solid shapes from which neutrons can escape, it has the smallest surface area. The more neutrons that are available to the supercritical mass, the more fissions will occur, and thereby, more energy will result. Another basic component of a gun-type device is the use of a reflector. A reflector is a metal shield that surrounds the spherical supercritical mass with the purpose of reflecting neutrons back into the core.

The material for a reflector should have a high probability of scattering neutrons back into the core, that is, it requires a high scattering cross-section and a low absorption cross-section.

A "tamper" is a layer of heavy metal that surrounds the reflector and fissionable core in order to contain the core long enough to obtain an appreciable yield of energy. As the explosive chain reaction takes places, the heat and pressure of fission forces the fissionable material apart, thereby stopping the chain reaction. The tamper holds the supercritical mass together long enough to achieve the desired yield.

An example of early gun-type devices, the Little Boy bomb weighed 8,900 pounds and was 126 inches long and 28 inches in diameter. The main sections of this bomb included the nose section, which contained the fissionable target, a 3-inch-diameter cannon barrel, and the breechblock of the cannon. A 6-inch-thick steel and tungsten carbide tamper weighing 5,000 pounds was in the nose section surrounding the fissionable target. The smooth-bore cannon barrel was 6 feet long, made of steel, and weighed about 1,000 pounds. A hole in the breechblock allowed for the projectile and propellant to be inserted. Later gun-type weapons were improvements to this first weapon in terms of efficiency, yield, size, and weight.

The low efficiency of the gun-type weapon was expected from the Little Boy explosion and illustrates one of the disadvantages of using this method to assemble a supercritical mass: It wastes highly enriched fissionable material. The amount of fissionable material necessary to make a gun-type weapon is two to three times the amount needed to make an implosion weapon. Another disadvantage to using the gun-assembly method is that it is based on a "single point detonation" device that is not safe in terms of accidental detonation. Implosion devices can be "two or more points safe" (that is, they can withstand explosive shocks in more than one direction without going supercritical). The timing of the initiator is another drawback to gun devices because the time at which the initiator functions cannot be controlled as precisely as in the implosion technique.

There are distinct advantages to the gun-type devices. The most important advantage is that the simplicity of the device increases its reliability. Early gun-type devices also were smaller and lighter than the implosion devices, making their delivery easier. Finally, since gun-type devices generally have a smaller diameter than implosion devices of the same yield, the gun-assembly method has been used to develop all U.S. weapons designed specifically for subsurface bursts.

Developing Technologies

Although there is a moratorium on developing new U.S. nuclear weapons, strategists and military officers in the United States often speak about the need to develop a precision-guided, "bunker buster" nuclear weapon that could hold at risk deeply buried and hardened targets. The gun-assembly method of creating a supercritical mass may be the preferred method for this application.

Emerging nuclear states are more likely to develop nuclear weapons utilizing a gun-type device to create a supercritical mass than they are to develop implosion weapons because the design is simpler and they can be developed without testing. Nonstate actors such as terrorist organizations also may strive to develop gun-type devices for the same reasons. Technology is not a stumbling block in creating a gun-type device. What slows and complicates the construction of this type of weapon is the need for large quantities of highly enriched uranium to create a supercritical mass.

—Don Gillich

See also: Fission Weapons; Implosion Devices; Proliferation

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H

HALF-LIFE

"Half-life" is defined as the time in which half of the radioactive nuclei in a radioactive substance will disintegrate or decay. A specific rate of radioactive decay is characteristic of each radionuclide. It is the time required for the disintegration of one-half of the radioactive atoms present when measurement starts. It does not represent a fixed number of atoms that disintegrate, but a fraction of the total number of atoms that were present at the measurement.

Radioactive elements are unstable and can decay spontaneously, causing them to produce radiation. Half of the residue present in a radioactive substance will disintegrate in another equal period of time and decay into another form. When several half-lives of a radioactive substance occur, only a fraction of the original radionuclides remains. Half-lives can range from a few seconds to hundreds of years depending on the type of radionuclide. Another term for half-life is "decay constant."

—Laura Fontaine

See also: Depleted Uranium (U-238); Isotopes; Plutonium; Radiation; Uranium

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HANFORD, WASHINGTON

Facilities at Hanford, Washington, were originally constructed in 1943 to produce plutonium for the first of America's atomic weapons. The facility is located on about 560 square miles of land astride the Columbia River in south central Washington state, near the city of Richland. The site's remoteness helped maintain the secrecy necessary for its work, and the river provided the water for cooling its reactors. By the 1960s there were nine reactors in operation at Hanford, only one of which supplied electricity to the civilian grid. The rest of the reactors were devoted to producing plutonium for weapons.

Hanford has proven to be environmentally problematic because it was built in haste and at a time when the problems associated with handling radioactive materials were little understood and production techniques related to weapons-grade plutonium were in their infancy. Mistakes were made. Radioactive waste was not disposed of properly. It was initially poured into water basins and storage tanks located at the Hanford site that eventually allowed radioactive and other toxic substances to leak into the surrounding soil and aquifers. Radioactive gases also were accidentally vented into the atmosphere.

Over the years, Hanford is reputed to have released more radioactivity than did the Soviet reactor accident at Chernobyl in 1986. The reactors at Hanford were finally shut down in 1980 because of concerns about their effect on the local environment. Ever since its closure, thousands of people have been employed at Hanford to clean up the facility.

—Rod Thornton

See also: Chernobyl; Manhattan Project; Plutonium; Radiation; Reactor Operations

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Steel drums full of class-A low-level radioactive waste buried in a large trench at the Hanford Nuclear Reservation. (Roger Ressmeyer/Corbis)

HARD AND DEEPLY BURIED TARGETS

Hard and deeply buried targets (HDBTs) are facilities that have been designed and constructed to make them difficult to identify, target, and defeat using currently available conventional weapons. Potential adversaries increasingly use such facilities to produce and store nuclear, biological, and chemical (NBC) weapons and to house military command and control centers. There are two categories of HDBTs. One is hardened by placing soil, concrete, and rock boulders atop a structure once it has been built. These "cut-and-cover" facilities are often built into an excavation and then covered. The other category includes tunnels and deep shafts, where protection is provided by existing rock and soil. There is a depth threshold at which it becomes more economical to tunnel rather than to excavate and cover. Below this threshold, costs generally are constant regardless of the depth of the tunnel, so tunneled facilities can exist hundreds of meters below the surface.

Tunneling has become the method of choice for NBC weapons producers because of the limitations of Western weapons capabilities to destroy deeply buried targets with conventional weapons and the increasing availability of advanced tunneling technologies. Hardened surface and cut-and-cover facilities may be vulnerable to existing air-to-surface penetrating weapons, but facilities housed in tunnels are nearly invulnerable to direct attack by conventional means. For this reason, the United States has explored numerous weapons options and damage or functional-kill mechanisms. One is to attack the tunnel portals with weapons that penetrate into the thinner cover rock above the portal or through the exterior doors, resulting in an internal detonation that can damage NBC weapons housed within deep tunnels.

—Peter Lavoy

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HARDENING

See Silo Basing

HARMEL REPORT

In the mid-1960s, the warming of East-West relations raised questions about the relevance of the North Atlantic Treaty Organization (NATO). Following the proposal of Belgian Foreign Minister Pierre Harmel, the December 1966 meeting of NATO foreign ministers commissioned a year-long study on "The Future Tasks of the Alliance." NATO allies adopted the Harmel Report in December 1967. It declared that NATO's mission was to seek détente with the Soviet Union and the Warsaw Pact as well as mounting deterrence against the Soviet threat and defense against a potential Warsaw Pact attack. Cold War negotiations for the Conference on Security and Cooperation in Europe (CSCE) and Mutual and Balanced Force Reduction (MBFR) grew out of NATO's Harmel initiative.

The Harmel Report stated that the alliance had "two main functions." The first was "to maintain adequate military strength and political solidarity to deter aggression and other forms of pressure and to defend the territory of member countries if aggression should occur." The second, and newly assigned, function of the alliance was "to pursue the search for progress towards a more stable relationship [with the East] in which the underlying political issues can be solved" (Sloan, p. 48).

NATO has continued the Harmel Report's mission by promoting post–Cold War arms control initiatives, particularly concerning weapons of mass destruction, establishing partnerships with all interested European states, and inviting qualified countries to join the alliance.

—Stanley R. Sloan

See also: Détente; Deterrence; Dual-Track Decision

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HEAVY BOMBERS

Rising to prominence during World War II, heavy bombers are aircraft with multiple engines, long range, and the ability to carry large quantities of munitions. They played a major role early in the Cold War, when their intercontinental ranges and enhanced payload capacities made them a key element in U.S. and Soviet nuclear deterrent forces.

Although their prominence diminished with the development of intercontinental ballistic missiles and submarine-launched ballistic missiles, heavy bombers possessed two important characteristics those systems did not: flexibility during missions and the ability to be recalled once launched. They were vulnerable to attack, while on the ground, however, because of the time required from the decision to launch to the moment of "escape" from their bases, and vulnerable in the air because of steadily improving air defenses. Heavy bombers also were slower to reach their targets than ballistic missiles, with flight times between U.S. bomber bases and Moscow measured in hours instead of minutes.

To overcome these weaknesses, the U.S. bomber force was placed on constant alert to avoid being surprised, and improvements were made to their survivability. For example, to evade Soviet air defenses, the B-52 was given a standoff mission, allowing it to fire long-range nuclear-armed cruise missiles at its targets outside the range of Soviet air defenses. Additionally, the B-1 was designed to fly fast and low to avoid air defenses, and the B-2 "stealth bomber" was designed to make it difficult to detect by radar.

With the end of the Cold War, heavy bombers began to play a greater role in conventional military operations. Their long range and high payloads again made them the weapon of choice when it came to delivering large amounts of ordnance against weakly defended targets. Although some bombers are still dedicated to the nuclear mission, they have played important roles as conventional bombers and cruise missile carriers in both Gulf Wars, Kosovo, and Afghanistan.

—Michael George

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HEAVY ICBMS

The first intercontinental ballistic missiles (ICBMs), such as the Soviet SS-6, the American Atlas, and the U.S. Titan I and II, were large, liquid-fueled rockets with payloads of 5 to 8 tons, the weight of thermonuclear warheads in the late 1950s. With a single warhead to destroy cities and large military installations, these missiles reaffirmed prevailing strategic assumptions. As smaller replacements, such as the Soviet SS-7, -9, and -11 and the U.S. Minuteman, appeared, the original heavy missiles were retired or reassigned to secondary missions.

The second generation of heavy ICBMs carried large numbers of much smaller reentry vehicles called MIRVs (multiple independently targetable reentry vehicles). The Soviet SS-18 was tested in 1973 with ten MIRVs and had an intercontinental throw weight (payload) of nearly 9 metric tons. This aroused concern in the United States that the Soviet Union would soon be able to destroy American ICBM fields in a disarming first strike using only a small portion of its total missile force. This superiority would make American threats of retaliation less credible.

Controlling heavy ICBMs became a major goal of American arms control efforts in the mid-1970s. The SS-18 was specifically defined as a heavy ICBM under the 1979 treaty resulting from the Strategic Arms Limitation Talks (SALT II). This limited the Soviet Union to no more than 308 heavy ICBMs and forbade testing an ICBM with more than ten warheads. Under the 1993 Strategic Arms Reduction Treaty (START II), destruction of SS-18 silos in Russia and Kazakhstan began in 1993–1994. The last silos were destroyed or converted, with the aid of U.S. funding, by the end of 2003. Decommissioned SS-18 missiles are being converted to service as Dnepr space launch vehicles.

The United States responded to the SS-18 with the MX Peacekeeper (LGM-118A). Although its throw weight was less than 3 tons—which in a technical sense did not make it a "heavy" missile—design innovations enabled the MX to carry ten warheads. Following the recommendations of the 1983 Scowcroft Commission Report, which was chaired by Lieutenant General Brent Scowcroft, USAF (ret.), fifty MX missiles were deployed in existing Minuteman silos. The first became operational in 1986. Under START II, all fifty MX ICBMs must be retired by 2004.

—Aaron Karp

HEAVY WATER

Heavy water, or deuterium oxide (D_2O), can moderate a reactor in which plutonium is bred from natural uranium. Although it looks like ordinary water, both hydrogen atoms have been replaced with deuterium, the isotope of hydrogen containing one proton and one neutron. It is present naturally in water, but in only small amounts, less than one part in 5,000. In the process of producing heavy water, deuterium molecules are separated from the vast quantity of water consisting of H_2O.

The importance of heavy water to a nuclear proliferator is that it provides a way to bypass uranium enrichment and produce plutonium for use in weapons. The world's first source of commercial heavy water came from the Vemork plant, Norway, as a by-product of the Norsk Hydro-Elektrisk station, which could produce 12 metric tons of heavy water per year. This facility, built in 1934, became the subject of German efforts to moderate a reactor, especially after the German occupation of Norway in 1940. Allied forces and the Norwegian resistance engaged in persistent and somewhat successful efforts to sabotage production. German interest in heavy water was one intelligence indicator that seemed to justify the decision to launch the Manhattan Project in the United States to obtain an atomic bomb before it could be acquired by German science (*see* Manhattan Project).

Besides the five declared nuclear weapons states, countries able to produce heavy water now include Argentina, Canada, India, and Norway. The Bruce Heavy Water Plant in Ontario, Canada, built in 1979, is the world's largest producer, capable of generating 700 metric tons of heavy water per year.

—J. Simon Rofe

See also: Deuterium; Isotopes; Plutonium; Uranium

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HEDGE

Although the 2002 Moscow Treaty (officially the Strategic Offensive Reductions Treaty, or SORT) limits Russia and the United States to 1,700–2,200 nuclear weapons deployed on strategic delivery systems, it does not specify how many nuclear weapons can be kept in reserve by both parties. To supplement its deployed warheads, the United States has maintained a ready reserve of nuclear warheads (referred to as the "hedge" force) in storage. These warheads are capable of being returned to military service on relatively short notice.

President Bill Clinton's administration planned to establish a hedge capability in its September 1994 Nuclear Posture Review. Not all warheads taken out of service in compliance with the Strategic Arms Reduction Treaty (START II) were going to be sent to the Pantex Plant near Amarillo, Texas, to be dismantled. Instead, about 2,500 to 2,700 weapons—the W62 and W78 warheads from the Minuteman III intercontinental ballistic missile, W76s from downloaded Trident submarine-launched ballistic missiles, and B61 and B83 bombs and W80 air-launched cruise missile warheads—were to be placed in the hedge force. The hedge was never officially created, however, since START II never entered into force (*see* Strategic Arms Reduction Treaty [START II]).

In its 2002 Nuclear Posture Review, the George W. Bush administration announced that it also would continue to maintain a "responsive force" of surplus nuclear weapons held in ready reserve as a hedge against emerging threats and as a way to address technical or safety issues that may emerge in the deployed force. The Bush administration also stated that it believes that the responsive force will serve to dissuade potential challengers from attempting to win a future nuclear arms race. The responsive force would allow the United States to field a large nuclear force faster than opponents could build nuclear weapons.

Critics charge that the responsive force, or any other stockpile scheme for nondeployed nuclear weapons, violates the goal of irreversibility in arms control and disarmament measures. They would prefer policies that completely dismantled nuclear warheads in such a way that they could never be redeployed.

—James J. Wirtz

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HIGHLY ENRICHED URANIUM (HEU)

Highly enriched uranium is a man-made substance that increases the level of fissile material in natural uranium to the point where it can be used for atomic reactor fuel or nuclear weapons. In nature, uranium consists largely of two isotopes, U-235 and U-238. The production of energy in nuclear reactors results from the fission, or splitting, of the U-235 atoms, a process that releases energy in the form of heat. U-235 is the main fissile isotope of uranium. U-235 and U-238 are chemically identical but differ in their physical properties, particularly their mass. The difference in mass between U-235 and U-238 allows the isotopes to be separated and makes it possible to increase, or "enrich," the percentage of U-235. All currently used enrichment processes directly or indirectly make use of this small mass difference. Naturally mined uranium has 0.7 percent U-235. Most power reactors use 3 to 5 percent enriched uranium, and weapons require 90 percent enriched uranium. During the Manhattan Project, enriched uranium was given the code name "oralloy," a shortened version of the name "Oak Ridge alloy," after the plant where the uranium was enriched in Tennessee. The term is still occasionally used to refer to enriched uranium. U-238 with extremely low U-235 content is known as depleted uranium and is considerably less radioactive than even natural uranium (*see* Actinides; Depleted Uranium [U-238]; Enrichment; Isotopes; Low Enriched Uranium [LEU]; Oak Ridge National Laboratory; Reactor Operations; Uranium).

Enrichment Processes

A number of enrichment processes have been demonstrated in the laboratory, but only two, the gaseous-diffusion process and the centrifuge process, are operating commercially. In both of these processes, uranium hexafluoride (UF_6) is used as the feed material. Molecules of UF_6 with U-235 atoms are about 1 percent lighter than the rest of the feed material, and this difference in mass is the basis of both processes. The gaseous-diffusion process involves forcing uranium hexafluoride gas under pressure through a series of porous membranes, or diaphragms. Since U-235 molecules are lighter than the U-238 molecules, they move faster and have a slightly better chance of passing through the pores in the membrane. The UF_6 that diffuses through the membrane is thus slightly enriched, and the gas that did not pass through is depleted in U-235 atoms. The process is repeated many times in a series of diffusion stages called a "cascade." Each stage uses a compressor, a diffuser, and a heat exchanger to remove the heat caused by compression of the gas. The enriched product is withdrawn from one end of the cascade and the depleted gas is removed at the other end. The gas must be processed through some 1,400 stages to obtain a product with a concentration of 3 to 4 percent U-235. At present, the gaseous-diffusion process accounts for about 40 percent of world enrichment capacity. Although they have proved durable and reliable, most gaseous-diffusion plants are now nearing the end of their design life. In the future, they are likely to be replaced by processes based on centrifuge enrichment technology.

Like the diffusion process, the centrifuge process uses UF_6 gas as its feed and makes use of the slight difference in mass between U-235 and U-238. The gas is fed into a series of vacuum tubes, each containing a rotor 1–2 meters long and 15–20 centimeters in diameter. When the rotors are spun rapidly, at 50,000 to 70,000 revolutions per minute (rpm), the heavier molecules with U-238 increase in concentration toward the cylinder's outer edge. There is a corresponding increase in the concentration of U-235 molecules near the center. The enriched gas forms part of the feed for the next stages, while the depleted UF_6 gas goes back to the previous stage. Eventually, enriched and depleted uranium are drawn from the cascade at the desired levels of purity. Although the capacity of a single centrifuge is much smaller than that of a single gas-diffusion stage, its capability to separate isotopes is much greater. Centrifuge stages normally consist of a large number of centrifuges in parallel. Such stages are then arranged in cascade similarly to those for diffusion. In the centrifuge process, however, the number of stages may only be ten to twenty, compared to a thousand or more for diffusion.

Laser enrichment processes, a possible third-generation technology, could bestow significant economic advantages because of the potential for lower energy inputs and capital costs. Atomic vapor laser isotope separation uses a laser to excite and ionize uranium atoms of a specific uranium isotope so they can be selectively removed. Molecular laser isotope separation also uses a laser, but to excite and ionize uranium hexafluoride molecules for selective removal. Another process is the Becker nozzle aerodynamic process, in which a mixture of gaseous UF_6 and helium is compressed and then directed along a curved wall at high velocity. The heavier U-238-bearing molecules move preferentially out to the wall relative to those containing U-235. At the end of the deflection, the gas jet is split by a knife edge into a light and heavy fraction, which are then separately withdrawn. Laser enrichment technology, however, is not yet ready for commercial use.

Use of HEU in Weapons

Uranium gun-assembly weapons are the easiest of all nuclear devices to design and build. It is generally considered impossible to prevent any nation that has the requisite amount of HEU from building one or more gun-assembled weapons. Electromagnetic separation was used to produce HEU for the first U.S. atomic weapon, and it was the technique used by Iraq in its efforts to develop nuclear weapons in the late 1980s. In the process, uranium atoms are ionized, given an electrical charge, then sent in a stream past powerful magnets. The heavier U-238 atoms are deflected less in their trajectory than the lighter U-235 atoms by the magnetic field, so the isotopes separate and can be captured by collectors. The process is repeated until a high concentration of U-235 is achieved. The American version of this process featured "calutrons" and was used in the Manhattan Project (*see* Manhattan Project).

The Little Boy bomb dropped on Hiroshima on August 6, 1945, was a uranium bomb. HEU is no longer being produced in the United States because all HEU is drawn from current stocks and commercial (non–weapons grade) sources.

—Gilles Van Nederveen

See also: Portsmouth Enrichment Facility

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HIROSHIMA

Hiroshima is a major port city in western Honshu, Japan, on the Inland Sea that was destroyed at the end of World War II by an atomic bomb. Historically a military center, it was the site of a major castle from the shoganate and later of the headquarters for several army elements, including the Second General Army, which was responsible for the defense of the home islands. During World War II it had a population of about 380,000, which was reduced by evacuations to 255,000. Manufacturing and storage facilities for military materiel were located in Hiroshima, and it was a point of embarkation for troops moving to the South Pacific.

By the summer of 1945, Japan was clearly defeated. The only remaining question was how the emperor's household was going to allow the war to end. The U.S. conquest of Okinawa had cost 49,151 American casualties. In addition, 763 U.S. aircraft were shot down and 36 U.S. ships were sunk, with another 368 damaged. The Japanese lost 110,000 men, 7,800 aircraft (1,465 in kamikaze attacks), and 16 ships. The Japanese civilians had been taught to defend the home islands to the death, so based on the costs of Okinawa, American military planners estimated that a ground invasion to secure surrender could cost 1 million American lives as well as millions of lives of Japanese civilians. The fire bombing of Tokyo had already resulted in 125,000

The center of Hiroshima, Japan, shortly after the first atomic bomb was dropped on August 6, 1945. (Bettmann/Corbis) civilian deaths in one night, with no offer of surrender forthcoming from the Japanese.

During the war, U.S. scientists and engineers working on the Manhattan Project had developed and produced three atomic bombs. One was used in the first test at the Trinity Site, and the other two were ready for use in July 1945. Desiring to bring the war to an end without additional American casualties, President Harry S. Truman authorized the use of an atomic bomb against Hiroshima.

The bomb dropped on Hiroshima was "Little Boy," a gun-assembly weapon designed at Los Alamos, New Mexico, with an explosive uranium 235 core using material extracted at the Oak Ridge National Laboratory, Tennessee. A B-29 bomber, the *Enola Gay,* piloted by Colonel Paul W. Tibbets, carried the bomb. It was dropped at 8:15 A.M. on August 6, 1945, on a bridge in central Hiroshima. The bomb detonated at 2,000 feet, with a force calculated at about 17,000 tons of TNT. Four and three-quarter square miles of the city were completely destroyed by the blast and resulting firestorm. Two-thirds of the buildings within 10 square miles surrounding the detonation were destroyed, including 26 percent of the production facilities in the city. The memorial cenotaph in the city's museum acknowledges that 61,443 people were victims of the bomb, but the United States estimated 71,379 known dead, with almost 70,000 additional people injured. Radiation sickness among the civilian population overwhelmed the surviving medical personnel and facilities. International medical aid did not arrive until September 1945, too late for many of the severe burn victims who needed hydration and supportive therapy.

Ground Zero in Hiroshima is a memorial park that includes the "Atomic Dome," a building preserved in its post-bomb state, a fountain, and other memorials as well as a large museum that describes the bombing from the Japanese perspective. The museum does not include documentation of the events leading to the bombing, information about atrocities committed by the Japanese military during the war, or any acknowledgment of Japan's role in the instigation of the Pacific War. The city of Hiroshima has been rebuilt as a thriving commercial area with a major port.

—Frannie Edwards

See also: *Enola Gay;* Fission Weapons; Gun-Type Devices; Little Boy; Manhattan Project; Radiation; Tinian

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HORIZONTAL ESCALATION

Horizontal escalation is the expansion of conflict to new geographic areas or to new actors in the international community. Advocates of the strategy suggest that key military or diplomatic advantages can be gained by expanding, or threatening to expand, hostilities to geographic areas not of the opponent's choosing. Critics of the concept believe that it squanders resources on secondary operations and creates new opponents gratuitously. During the Cold War, the Ronald Reagan administration, for example, adopted the military strategy of horizontal escalation. In the so-called maritime strategy, Reagan officials argued that in the event of war along the inner German border, U.S. forces would launch attacks against the Soviet Far East to tie down Soviet forces that might be used in the European theater. Strategies based on horizontal escalation require increases in force structure and defense spending in order to maintain the military forces needed to fight the war along the "central front" while deploying additional forces to launch secondary attacks against the enemy.

Vertical escalation, by contrast, refers to an increase in the level of violence in a given conflict rather than the expansion of the conflict to new regions. The decision to employ nuclear weapons to stop a conventional attack by armored units, for instance, would be considered a vertical escalation of a given conflict.

—Laura Fontaine

See also: Escalation; Inadvertent Escalation

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HOT LINE AGREEMENTS

The "Hot Line" between Washington and Moscow is a series of dedicated transmission lines to ensure immediate communication between the two superpower leaders in time of crisis. While the 1958 Surprise Attack Conference recessed without achieving conclusive results, proposals from the conference stimulated U.S. and Soviet technological research on reducing the danger of an accidental nuclear war. The Cuban missile crisis of October 1962 underlined the importance of prompt, direct communications between the heads of state of the United States and the Soviet Union. In December 1962, a U.S. working paper submitted to the Eighteen Nation Disarmament Committee (ENDC) in Geneva proposed a number of cooperative measures, including establishment of dedicated transmission lines between major capitals to ensure reliable and rapid communication in times of crisis (*see* Accidental Nuclear War; Cuban Missile Crisis).

On June 20, 1963, American and Soviet representatives to the ENDC completed negotiations and signed a "Memorandum of Understanding Between the United States and the Union of Soviet Socialist Republics Regarding the Establishment of a Direct Communications Link." The link consisted of two terminal points with teletype equipment, a full-time duplex wire telegraph circuit, and a full-time duplex radiotelegraph circuit.

The Hot Line Agreement was the first bilateral agreement that sought to reduce the risk of a nuclear war stemming from accident, miscalculation, or surprise attack. Advances in technology in the 1960s offered the possibility of greater reliability for the communications link. During the Strategic Arms Limitation Talks (SALT I and II), a special working group was established to improve Washington-Moscow direct communications. On September 30, 1971, the Hot Line Modification Agreement was signed in Washington, D.C. The improved system included twin U.S.-Soviet satellite communications circuits, along with multiple terminals, in each country. The system continues to be upgraded and operated on a daily basis.

—*Patricia McFate*

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HYDROGEN BOMB

The hydrogen bomb, also known as the H-bomb, the fusion bomb, and the thermonuclear bomb, is based on nuclear fusion, where light nuclei of hydrogen or helium atoms combine together into heavier elements and release large amounts of energy. The effects of a hydrogen bomb vary depending on the size of the weapon, but it is easily capable of devastating 150 square miles by blast and generating searing heat effects and radioactive fallout for more than 800 square miles.

The U.S. decision to develop hydrogen bombs began on September 23, 1949, when President Harry S. Truman announced that the Soviet Union had tested its first atomic bomb. The announcement caused panic in the country and created a flurry of activity in scientific and political circles. On January 31, 1950, President Truman announced the United States' reaction to the Soviet nuclear test, a crash program to develop a hydrogen bomb.

Physicist Edward Teller, mathematician Stanislaw Ulam, and other scientists spent more than a year of research in Los Alamos, New Mexico, solving the technical problems involved in producing a hydrogen bomb. On November 1, 1952, the first hydrogen bomb was detonated at the Enewetok Atoll with an explosive power of 10.4 million tons (megatons) of TNT. It caused an island to disappear and created in its place a crater a mile wide and 175 feet deep. A deliverable bomb was developed and successfully tested in 1954.

The Soviet Union tested its first true fusion bomb on November 22, 1955, using a 1.6-megaton device designed by Andrei Sakharov. On October 31, 1961, the Soviet Union detonated a device at their range on the Arctic Ocean island of Novaya Zemyla; it turned out to be history's largest nuclear explosion, the Tsar Bomba, with a yield of 58 megatons.

On May 15, 1957, the United Kingdom successfully detonated a fusion device at Christmas Island with a yield of between 200 and 300 kilotons—surprisingly low. In September of that year, the United Kingdom detonated a hydrogen bomb with a yield of 1.8 megatons.

China next entered the hydrogen bomb club on June 17, 1967, when it tested a bomb with a yield of 3.3 megatons that was designed and manufactured with little assistance from the Soviet Union.

France tested its first hydrogen bomb at the Fangataufa Atoll on August 24, 1968. It had a yield of 2.6 megatons. Other nations, such as India, Israel, and Pakistan, have either tested fusion devices or claim to have the capability to produce them.

The hydrogen bomb is based on the tremendous power of nuclear fusion—the collision of neutrons

American's first hydrogen bomb test, the 10-megaton Mike shot in the Marshall Islands of the Pacific, November 1952. (Bettmann/Corbis)

with the nucleus of an unstable isotope of hydrogen, either deuterium or tritium, under high temperatures. The reason for the power of fusion is originally found in Albert Einstein's famous equation, $e = mc^2$, in which mass and energy are directly related and, during the right conditions, interchangeable. By combining two atoms into one, when the product weighs less than its original components, the excess weight can be translated into a tremendous amount of energy (*see* Deuterium; Fusion; Isotopes; Tritium).

The hydrogen bomb explosion is actually a chain reaction triggered by a normal fission bomb that produces temperatures and pressure within the thermonuclear device that allow for nuclear fusion. A modern hydrogen bomb has at its center an atomic bomb surrounded by a layer of lithium deuteride (the isotope of hydrogen with a mass number of two). This is surrounded by a thick outer layer known as the "tamper," which is often composed of fissionable material and functions to hold the contents together to contain the pressure and heat long enough to obtain a larger explosion. Neutrons from the atomic explosion cause the lithium to fission into helium, tritium (the isotope of hydrogen with mass number three), and a tremendous amount of energy. The initial atomic explosion also supplies the heat required for fusion, raising temperatures within the thermonuclear device to as high as 400 million degrees Celsius. Enough neutrons are produced in the fusion reactions to produce further fission in the core and to initiate fission in the tamper.

Like other large nuclear explosions, the hydrogen bomb creates an extremely hot zone near the blast site. Because of the high temperature, nearly all of the matter near the blast site is vaporized. The high pressure generated by such a large blast progresses away from the center of the explosion as a shock wave. It is this wave, containing most of the energy released, which is responsible for most of the destructive mechanical effects of a nuclear explosion. The details of shock-wave propagation and its effects vary depending on whether the burst is in the air, under water, or underground.

Like other large nuclear blasts, hydrogen bomb blasts scatter a large amount of radioactive material. Even low concentrations of radiation can be lethal, causing death and illness for years after the blast.

—Abe Denmark

See also: Fusion; Implosion Devices; Nuclear Weapons Effects; Radiation; Thermonuclear Bomb

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I

IMPLEMENTATION

The process of complying with treaty provisions and verifying such compliance is called "arms control implementation." Arms control treaties and agreements are intended to enhance international security and to preserve peace by allowing states to take measures to eliminate military weapons, control weapons technology, or promote understanding between those who sign the agreement. Most treaties or agreements contain confidence-building and verification provisions. Confidence-building measures may include data declarations, formal visits, challenge inspections, systematic inspections, continuous monitoring of key facilities, and aircraft overflights geared toward ensuring compliance with the provisions of a specific treaty. Some treaties, such as the Biological (and Toxin) Weapons Convention (1975), have no verification provisions at all; others, such as the Chemical Weapons Convention (1997), call for short-notice, detailed, intrusive inspection verification measures by an international inspection team. Challenge inspections, probably the most intrusive type of verification measure, are usually governed by complex and comprehensive rules and procedures authorizing an international team of investigators to explore concerns about possible noncompliance with arms control agreements by visiting sites where prohibited activities may be occurring.

In the United States, responsibility for arms control implementation and compliance is largely the responsibility of the Department of Defense (DOD) and the individual services. Within the U.S. Navy, for example, DOD Directive 2060.1 gives responsibility for arms control implementation to the director of the Naval Treaty Implementation Program (NTIP), who supports the assistant secretary of the Navy for research, development, and acquisition (ASN [RDA]) in the planning and implementation of all arms control agreements that affect the Department of the Navy. ASN (RDA) has designated NTIP as the executive agent to carry out the daily work of treaty implementation and compliance.

—James J. Wirtz

See also: Arms Control; Confidence- and Security-Building Measures; Ratification; Verification

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IMPLOSION DEVICES

An implosion device is a nuclear weapon that relies on a spherical compression of fissile material to achieve critical mass. It is more sophisticated and efficient than the gun-type compression system. It was first designed, built, and tested by the Manhattan Project, the World War II Anglo-American program that constructed the first nuclear weapons.

History and Background

During the initial phase of the Manhattan Project two designs were proposed. One was the gun-type device, which was attractive because of its simplicity, ease of construction and operation, and high reliability (*see* Gun-Type Devices). The second design, the implosion device, was also attractive because it offered a more elegant solution to producing nuclear fission and did not require highly enriched uranium, which was very difficult to produce (*see* Highly Enriched Uranium [HEU]; Uranium). Using a similar amount of fissile material, an implosion device will produce a far greater explosive yield than a gun device. Serious material and engineering hurdles had to be overcome, however, before an implosion device became a reality.

The implosion device required extensive testing using explosives, detonators, triggering mechanisms, and timers to arrive at a design that would work. Therefore, both gun and implosion designs were developed by the Manhattan project: The gun-type device would be immediately available for wartime use, and the implosion device would be developed to create the next generation of more sophisticated and powerful nuclear weapons.

In the summer of 1944, a new impetus emerged for the development of the implosion device with the discovery that nuclear reactors created an isotopic impurity, plutonium 240, which could not be used in gun-type assemblies. All of the plutonium for atomic bombs would have to be made in reactors, so the only way to make use of the plutonium coming from the Hanford, Washington, production reactors built by DuPont was to find a way to perfect implosion (*see* Hanford, Washington; Isotopes; Plutonium).

Los Alamos National Laboratory organized Division GX (for "gadget explosive") to develop the nuclear and high-explosive components of the implosion device. Dr. Robert Oppenheimer, head of the Manhattan Engineering Project, created the Trinity Project in September 1944. A design team at Los Alamos National Laboratory, New Mexico, arrived at a functional design far ahead of schedule. As a result, the implosion device was constructed simultaneously with the gun-type device. On July 16, 1945, the Trinity nuclear device was detonated at the Alamogordo Bombing Range in New Mexico (*see* Manhattan Project; Trinity Site).

The theoretical expectations about the greater efficiency of the implosion device were confirmed by use of both types of weapon in combat. "Little Boy," the gun-type device dropped on Hiroshima, had an estimate yield of approximately 12.5 to 20 kilotons. "Fat Man," the implosion device dropped on Nagasaki, had a yield of approximately 21–23 kilotons.

Technical Details

The fission implosion device consists of arming and power mechanisms and the physics package (known as the "pit"; *see* Pit). The core is usually plutonium 239 with a beryllium casing wrapped with an explosive material. The high-explosive shell is lined by detonators at a predetermined spacing to produce uniform compression of the fissile material and ensure complete, instantaneous detonation. When the explosive is detonated, an inwardly directed implosion wave is produced, uniformly crushing and tamping the fissionable material. The decreased surface volume, plus the increased density, makes the mass supercritical. This is what is often referred to as "splitting the atom." From this chain reaction, energy is released in an uncontrolled fashion. This energy takes the form of intense heat, pressure from the shock wave created by the blast, electromagnetic pulse, and radiation. The size of the blast is determined by the amount of fissile material and the efficiency with which it was compressed. Early designs were not efficient—that is, they were "dirtier" than current weapons, producing great amounts of radioactive material (*see* Fallout; Radiation).

In a hydrogen (or fusion) implosion device, the process of creating a nuclear explosion contains several additional steps. The pit must include a neutron source, usually tritium gas. This is surrounded by plutonium 239 (Pu-239), then uranium 235 (U-235), a vacuum, uranium 238 (U-238), a beryllium casing, and an explosive casing. The nuclear explosion depends on fission to release the binding energy in certain nuclei, which is rapid and violent. The fissile materials, such as plutonium and uranium, can be split into two roughly equal-mass fragments when a neutron is forced into them. A self-sustaining chain reaction occurs.

The minimum mass of fissile material for a nuclear chain reaction is called a critical mass (*see* Criticality and Critical Mass). The amount of material needed to create a critical mass depends on the material used as well as on the surrounding material, known as a reflector or tamper. This surrounding material reflects the escaping neutrons back into the critical mass. For example, a bare sphere requires 56 kilograms (kg) of U-235 and 11 kg of Pu-239. A thick tamper requires only 15 kg of U-235 and 5 kg of Pu-239. Critical mass decreases rapidly as density increases, so an implosion device requires substantially less nuclear material then a gun-type device. For example, Fat Man used 6.2 kg of plutonium and produced a yield of 23 kilotons. Until 1994, the Department of Energy stated that 8 kg would be needed to make a small nuclear weapon, but later experiments proved that 4 kg would be sufficient. Some scientists believe that 1 kg of plutonium would be adequate in modern designs to create a critical mass.

A second type of hydrogen implosion device, the Teller-Ulam fusion bomb, uses thermal radiation. This type of bomb was created in 1953 at a time when tritium gas was difficult to obtain and store (*see* Tritium). A fission implosion device is used as the triggering mechanism to release thermal radiation in the form of soft X-rays. The X-rays are directed into the pit, setting off a secondary stage that leads to fusion reaction. The bomb casing included an implosion fission bomb and a cylinder casing (tamper) of U-238. Within the tamper are lithium deuteride (fuel) and a hollow rod of Pu-239. A shield of U-238 and plastic foam fills the spaces in the bomb casing. The fission bomb explodes, giving off X-rays, exerting pressure against the lithium deuterate, causing it to compress thirty-fold, and initiating fission in the plutonium rod. The neutrons released in this process go into the lithium deuterate to make tritium, yielding fusion reactions that result in a fusion explosion.

Current Status

Since the deployment of the Fat Man device, radical improvements and refinements have occurred in the design and execution of implosion devices. Less fissile material is required, and improved explosives and casings have led to smaller and lighter weapons that can produce enormous explosive yields. These devices are currently used in intercontinental ballistic missiles, theater tactical weapons, cruise missiles, torpedoes, and man-portable devices.

The largest implosion device ever detonated (estimated at 56 megatons of yield) was produced by the Soviet Union. Today, high-yield devices are gradually being retired from nuclear arsenals because low-yield weapons designed for battlefield use are believed to offer a more credible deterrent threat. The increased accuracy of modern delivery systems also now allows smaller nuclear weapons to destroy very hard or deeply buried targets (*see* Accuracy; Credibility; Deterrence).

The B61 series of bombs is the largest family of implosion devices used by U.S. forces. Production was first begun in 1966, and they have been produced for more than thirty years at Los Alamos National Laboratory. This bomb can be delivered as a free-fall air burst, a retarded air burst, a free-fall surface burst, or in "laydown" mode from an aircraft flying as low as 50 feet and using a parachute to slow the bomb's descent and control its trajectory. This type of bomb has been carried by the B-52, FB-111, B-1, and B-2 bombers. Tactical versions with lower yield have been carried by the United States and other members of the North Atlantic Treaty Organization (NATO) aboard a variety of tactical aircraft (for example, F-100, F-104, F-15E, F-16, F-111, F-117, and Tornado). The U.S. Navy and Marines have used the B61 in their A-6, A-7, and F/A-18 aircraft.

Two strategic versions of the B61 are currently in use. The B61-7 is a variable yield gravity bomb for the B-52 and B-2. The B61-11 is an earth-penetrating weapon for the B-2. The tactical weapons are the B61 Mods 3, 4, and 10. These are stored within the United States at Nellis Air Force Base, Nevada, and Kirtland Air Force Base, New Mexico, and probably with additional fighter wings in North Carolina and New Mexico. The B61s also have been stored with U.S. Air Force units in Britain, Germany, Greece, and Turkey and have been held in U.S. custody for NATO air forces in Belgium, Germany, Italy, and the Netherlands.

Although implosive devices are fairly simple to design in theory, building one is quite difficult, making them an unlikely initial path for emerging nuclear weapons states. The machining tolerances necessary for the casing, the layering of explosive material, the positions of the detonators, and the design of the triggering mechanism for the detonators are extremely complex. Manufacturing and assembly of a nuclear bomb would require a large organization's financial backing to develop the tools and expertise required. Although basic implosion designs are now the stuff of high-school physics, individuals or small terrorist cells continue to lack the ability to manufacture a nuclear weapon that utilizes implosion to create a fission reaction.

Some nations that have developed nuclear weapons, such as South Africa and Pakistan, have only developed gun-type devices. North Korea could easily possess a gun-type device. The United States, Russia, Britain, France, India, and China possess implosion devices.

Developing or Future Technologies

Further improvements in the design and performance of nuclear weapons will likely be based on implosion-type devices. Variations in design, though theoretically possible, appear to be less practical. A biconical mini–nuclear weapon design, for instance, has been created to provide a low-yield battlefield weapon with a 1- to 2-kiloton yield. The biconical design uses two shaped charges facing each other with the fissile material between them. Upon detonation, the shock wave of each charge is directed into the fissile material. This method was apparently an attempt to combine the simplicity and reliability of a gun-type device with the efficiency of a implosion device.

—Dan Goodrich

See also: Fission Weapons; Proliferation

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IMPROVISED NUCLEAR DEVICES

Improvised nuclear devices—sometimes referred to as "crude nuclear weapons"—are simple, unsophisticated atomic bombs. They would probably utilize a gun-type device to create a critical mass and explosive yield. Although these weapons will probably not be based on complicated designs that use a combination of nuclear fission and fusion to boost the nuclear explosive yield of a weapon to extremely high levels, they could have an explosive yield of up to a few tens of kilotons.

Essential for any nuclear fissile weapon design is a swift compression of the fissile material to create a supercritical mass and to avoid preignitions that would cause the device to fizzle (that is, no yield or minimal explosive yield) (*see* Criticality and Critical Mass). The requirements for creating an improvised weapon depend on the type of fissile material used and the mass, density, and geometry of the fissile material. The probability of creating a critical mass increases with the quantity and density of the fissile material available.

To create a critical mass in a gun-type design, one subcritical mass is fired using conventional explosives into another subcritical mass of fissile material. Highly enriched uranium is the preferred fissile material for gun-type weapons. Depending on the design and sophistication of the device, 15 to 25 kilograms of highly enriched uranium could be sufficient to produce a functional improvised nuclear device (*see* Gun-Type Devices; Highly Enriched Uranium [HEU]).

If terrorists were to construct their own nuclear weapons, they would probably select a gun-type device. This type of weapon is easy to construct, and terrorists would probably not be attracted to more efficient ways of creating a critical mass to generate high yields. Gun-type devices are relatively unsafe in the sense that they are more likely to detonate accidentally than other nuclear designs, but terrorists might not be concerned about the safety of their nuclear arsenal. Gaining access to enough high-quality fissile material to construct a nuclear weapon is probably the greatest obstacle faced by state and nonstate actors when it comes to creating an improvised nuclear device.

—Morten Bremer Maerli and James J. Wirtz

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INADVERTENT ESCALATION

Inadvertent escalation occurs when a state unintentionally or unexpectedly crosses the nuclear threshold in response to a conventional attack. In military escalation, adversaries increase the intensity of violence or widen the geographical scope of a war in the attempt to gain victory. During the Cold War, the concept of escalation generally referred to the leap from conventional military warfare to the use of nuclear weapons.

The decision to escalate can be viewed as a cost-benefit calculation of the possibility of gaining important objectives and the likelihood of counter-escalation by the enemy. This contrasts with the concept of inadvertent escalation, where crossing the nuclear threshold is not intended by legitimate political or military authorities and arises from the unexpected results of conventional attacks. These escalation-producing conventional attacks could take several forms: For example, conventional forces could come into direct contact with the adversary's nuclear forces, possibly threatening their survivability and hastening their use; conventional attacks could degrade the command and control of the adversary's nuclear forces; or conventional attacks could be mistaken for a preemptive first strike, starting a nuclear alert cycle that leads to launch on warning by an opponent who believes that an attack on its forces is imminent.

The difference between deliberate and inadvertent escalation was illustrated during the 1962 Cuban missile crisis. When the United States announced a quarantine of Cuba, U.S. armed forces, including nuclear forces, were put on full alert. This deliberate escalation on the part of the United States was meant to warn Moscow to remove its missiles from Cuba.

While these deliberate actions were taking place, unintended events transpired. For example, a U-2 reconnaissance plane overflew the Soviet Union (the overflight was caused by a navigational error), and a squadron of U.S. fighter aircraft was scrambled to escort the errant U-2 out of Soviet airspace. The Soviets could have mistaken these incidents as a nuclear attack and launched a retaliatory nuclear strike against the United States. How close the world came to inadvertent nuclear escalation during the Cuban missile crisis was not fully appreciated until classified documents were released many years later.

—*Peter Lavoy*

See also: Cuban Missile Crisis; Escalation; Horizontal Escalation

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INDIAN NUCLEAR WEAPONS PROGRAM

In 1964, Indian Prime Minister Lal Bahadur Shastri promoted research and development into what was called a "Subterranean Nuclear Explosion for Peaceful Purposes." India detonated its first atomic device ten years later, on May 18, 1974, using fissile material derived from a Canada Deuterium Uranium (CANDU) reactor. Although India had previously claimed its atomic forays were solely for peaceful nuclear purposes, in May 1998—after testing five nuclear devices—India formally declared itself a nuclear weapons state. India is not a member of the Nuclear Nonproliferation Treaty (NPT) of 1968, however, and refuses to join, claiming that the NPT is a discriminatory regime. According to the Wisconsin Project's *Risk Report* (2003), India may possess sufficient fissile material to produce up to 100 nuclear warheads.

In establishing its nuclear command and control organization, India promulgated its own nuclear doctrine in 1999, claiming its policy was "no first use" and that its nuclear forces were intended to provide only a "credible minimum deterrent." The Indian government also claims that it has nuclear devices possessing the capability of low yields to 200 kilotons involving fission, boosted-fission, and two-stage thermonuclear designs (*see* Fission Weapons; Thermonuclear Bomb). India is reportedly pursuing a triad of nuclear forces to include air-, land-, and sea-based delivery platforms (for example, submarines). As of 2004, India's primary means of delivering nuclear warheads included ballistic missiles such as the Privthi I short-range ballistic missile (SRBM) and the medium-range Agni II. For aircraft delivery, India would most likely use modified versions of the MiG-27 Flogger and the Jaguar IS/IB. Intense enmity and occasional wars with Pakistan—as well as ongoing conflict in the disputed Kashmir region—have led to even more heightened tensions in the twenty-first century because the two South Asian nations both possess nuclear weapons.

Estimates of how many warheads India possesses range from 30 to 150. At the end of 1999, India was believed to possess 240–395 kilograms of weapons-grade plutonium, which could be used to build 45–95 nuclear warheads. The amount of plutonium that could be extracted from India's six heavy-water nuclear power plants could be used to build as many as 200 nuclear devices (*see* Heavy Water; Plutonium).

Indian troops and short-range ballistic missiles near the Pakistani border, May 2002. (Arko Datta/Reuters/Corbis)

In August 1999, the Indian government released a draft nuclear doctrine prepared by the nonofficial National Security Advisory Board. The Indian government continues to develop its nuclear doctrine and has stated that no-first-use of nuclear weapons and civilian control over nuclear weapons are key to their effort to develop a credible minimal deterrent based only on retaliation. Indian officials also assert that global, verifiable, and nondiscriminatory nuclear disarmament remains as a "national security objective."

The Indian government announced the establishment of the Nuclear Command Authority (NCA), which will manage and administer all of India's nuclear and strategic forces, in January 2003. The NCA includes the civilian Political Council, headed by the prime minister, which will have sole authority over the release of nuclear weapons.

In May 1998, India announced a voluntary moratorium on further nuclear testing, excluding computer simulation and subcritical tests. India is developing several ballistic missile systems, particularly the Agni I with a tested range of 800 kilometers, Agni II with a demonstrated range of more than 2,000 kilometers, and the Agni III with a planned range of up to 3,500 kilometers. India and Russia are jointly developing a supersonic cruise missile, the Brahmos, with a range of 280 kilometers. The Brahmos entered production in 2004. India also is working on at least two naval systems that may be equipped to carry nuclear warheads.

—Claudine McCarthy
and Jolie Wood

See also: Negative Security Assurances; Nonproliferation; Nuclear Nonproliferation Treaty; Pakistani Nuclear Forces; Strategic Forces

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INERTIAL NAVIGATION AND MISSILE GUIDANCE

Although large rocket engines are the sine qua non of long-range missile capabilities, engine capability alone is useless without an effective guidance system. The basic problem of missile development is achieving accurate flight over a specific trajectory. As missile ranges increase, accuracy tends to decrease proportionately. Through most of the Cold War, missile accuracy was an essential consideration in nuclear strategy. Since the end of the Cold War, guidance has offered one of the most important bottlenecks for restraining emerging missile programs through export controls. Technical innovation in the 1990s, however, made it much easier and cheaper to achieve extremely high accuracy at long ranges. This has the potential to eliminate one of the most important levers on the international control of missile proliferation.

Range and Accuracy Tradeoffs

At short ranges, sufficient accuracy to assure damage with conventional high-explosive warheads usually can be achieved with "passive guidance" alone. The small size of the rockets permits very rapid acceleration, which when combined with clean aerodynamic design compensates for atmospheric disturbances such as wind. Short-range systems, such as multiple-launched artillery rockets, are fired in large volleys, relying on numbers to compensate for lack of accuracy. The effectiveness of these weapons was demonstrated by the destruction of large swaths of Kabul, Afghanistan, in 1994, inflicted entirely with thousands of unguided artillery rockets.

Beyond ranges of about 70 kilometers (km), however, "active guidance" becomes essential to ensure accurate flight. At greater ranges, accuracy declines, creating an incentive to turn from conventional high-explosive armaments to weapons of mass destruction, especially nuclear warheads. Less costly guidance methods, such as radio-command guidance or strap-down gyros, which are constructed by suspending a rotor on at least three rings to reduce the effect of outside torque on the rotor's own spinning motion, may be sufficient to ensure adequate capability to ranges of about 300 km. Even at these ranges, the greater financial cost of the rockets makes it progressively harder to rely on sheer numbers to compensate for weakness of design. This explains why long-range missiles—especially those capable of traveling beyond 1,000 to 1,200 km—tend to be designed to carry nuclear payloads.

Guidance Alternatives

The least costly and technically demanding guidance approach is to mount the gyros and accelerometers in a rigid package attached directly to the airframe of the missile or rocket. Known as "strap-down guidance," this type of system is not especially accurate, a problem that was apparent in its first major application in the V-2. Strap-downs remain widespread in technically less demanding roles. It is the technique used in Scud ballistic missiles and Silkworm cruise missiles, for example. The approach also has been improved by adding another guidance system to provide correction. In an air-to-air missile such as the AMRAAM or AIM-9, for example, strap-down guidance maintains the missile in stable flight, while infrared or radar guidance directs it to the target.

Early intercontinental ballistic missiles (ICBMs), such as the American Atlas-D and the Soviet SS-7, relied on strap-down gyros augmented by radar tracking and radio control. Radio or command guidance was highly effective, but it worked only so long as the missile was above the horizon, beyond which the curve of the Earth degraded signals. It also suffered from the risk of jamming and interference. Although it was abandoned by the superpowers as quickly as they could replace it with more advanced systems, it appears to have found new applications among emerging missile powers. As radio signal–processing abilities improved in the 1970s and 1980s, command guidance became more reliable and appealing again, especially for short- and medium-range applications.

Because control of the vehicle relies on engines and aerodynamics for directional control, active guidance is possible only so long as the engines are burning or the vehicle is inside the Earth's atmosphere. Following engine burnout, which typically happens well into outer space (3 to 5 minutes into the flight depending on the size and range of the rocket), the vehicle begins to coast along its ballistic trajectory. In long-range missiles, coasting is no problem. Inaccuracies will build up again, however, as the reentry vehicle begins descent upon return to the atmosphere.

The inevitable deterioration in accuracy at the end of a warhead's trajectory can be offset through the use of small vernier engines in space or through aerodynamic surfaces mounted on the reentry vehicle. As the reentry vehicle approaches its target, guidance can be switched to "terminal guidance" mechanisms, usually relying on optical or radar sensors. These techniques were first deployed in the U.S. cruise missiles and Pershing II intermediate-range systems developed in the 1970s. Relying on a photographic or radar image of the target, these systems greatly improved accuracy. But there is a tradeoff involved in using improved guidance systems. Because terminal guidance requires that the guidance package and maneuvering systems be carried the full length of the trajectory, the weight and drag associated with this additional payload can severely reduce the maximum range of the missile itself.

The Dominance of Inertial Navigation

The need for a completely autonomous guidance system capable of sufficient accuracy to ensure effective attack with nuclear weapons created enormous pressure on designers in the 1950s and early 1960s. The preferred solution was the inertial navigation system (INS).

INS technology relies on gyros mounted on independent gimbals that allow them to move freely, unaffected by the motion of the rocket carrying them. Sensors mounted around the gyro detect changes in angular motion. Each gimbal also carries an accelerometer to measure changes in velocity. Normally three gyros and three accelerometers, one for each axis of motion (roll, pitch, and yaw), their associated sensors, and their gimbaled mountings are combined in a single package. In addition, an INS must have motors to power the gyros and lubrication systems to minimize friction on the moving elements. The result is a stable platform able to detect even very small changes in direction and velocity. The complete platform looks like a metal sphere, 6 to 18 inches in diameter, covered with access panels and adjustment points. External elements convert its signals into guidance commands that direct the engine and aerodynamic surfaces of the vehicle.

The first stable platform INS was designed for improved versions of the Nazi German V-2, but it could not be flown until after the war. Subsequently perfected at the U.S. Army's Redstone Arsenal by General Electric in the 1950s, this design equipped the first generations of American ballistic missiles, including the Redstone, Jupiter, Atlas-E/F, and Pershing I missiles. The early sets were heavy, prone to break down, and suffered from significant drift (or inaccuracy), but they were good enough to ensure that a nuclear-armed missile would reach its target. At the longest ranges, though, the extensive lethal radius produced by large thermonuclear weapons was the only way to compensate for the limited accuracy of early INS technology.

A major source of friction and drift were the bearings where the gyros and accelerometers were attached to the guidance platform. In the German design, these were made from jewels (usually ruby or sapphire) identical to those used in watches of the day. An alternative design pioneered in the 1950s by Charles Stark Draper of the Massachusetts Institute of Technology (MIT) replaced the mechanical bearings with floated-ball systems that suspended the gyros in an oil film. This was followed with air bearings, which eliminated the need to physically link the gyro to its suspending gimbals. This last innovation created systems capable of even greater accuracies.

The Draper approach culminated in the Northrop AIRS (Advanced Inertial Reference Sphere) guidance system for the MX missile. The AIRS houses gyros and accelerometers within a beryllium sphere that floats in a fluorocarbon fluid. The whole system is floated within an outer shell and can thus rotate in any direction. Although details have not been declassified, AIRS is said to have achieved unmatched accuracy. Its faults reportedly contributed less than 1 percent of the inaccuracy in the MX ICBM's 100-meter circular error probable (or CEP, the radius within which a warhead or bomb will land 50 percent of the time). Such precision came at great cost and production difficulty. The package reportedly has 19,000 parts. In 1989, a single accelerometer used in the AIRS (there are three) cost $300,000 and took six months to manufacture.

In the best INS, gyro drift can be as low as about 0.001 degrees per hour, which is roughly the theoretical minimum of the system. Even this translates to a positional error of about 0.1 nautical miles per hour of operation, a major consideration, especially when the navigation system must operate at high alert for extended periods and cannot necessarily be aligned immediately before flight. In an ICBM with a flight time of about 30 minutes, such inaccuracies still can become serious enough to compromise a mission. A more typical INS suffers from gyro drift of 0.01 degrees per hour, or 1 nautical mile per hour.

The high cost and limited reliability of the best INS technology did not undermine its enormous advantages. Improvements in accuracy made it possible for the United States to switch from targeting cities to targeting opponents' missile fields. The accuracy of the best air-bearing INS also made it possible for both the United States and Russia to reduce missile armament from megaton to kiloton warheads because they could still be assured of destroying the intended target.

Beyond Inertial Navigation

The great cost, high-maintenance requirements, and limited reliability of INS weapons showed the limits of the INS approach to missile guidance. Alternatives were invented in the 1960s and 1970s and began to be used in the 1980s. Initially, these innovations focused on cheaper ways to construct gyros, such as using laser gyros, which rely on a beam of light instead of mechanical methods. Although these were cheaper and more robust than the older systems, they suffered from poor accuracy, making them unsuitable for long-range missile applications. This appears to be changing as accuracies of 0.01 degrees per hour are now achieved using these systems. Even more reliable are fiber-optic gyros, which have achieved drift performance up to 1 degree per hour. The latter are used by commercial airliners but have yet to reach any confirmed missile applications. Both approaches cost less than traditional INS technology.

In the late 1980s, developments in gyros based on micro-circuitry began to show greater promise. Based on micro-electromechanical systems (MEMS), these use microscopic components carved in silicon chips. The technology is most familiar in the accelerometers used to ignite car airbags in collisions. MEMS makes possible low-cost, strap-down gyros and accelerometers with drift rates of as much as 20 degrees per hour. A newer approach using tuning-fork technology is expected to achieve drift rates of 1 to 10 degrees per hour in a package the size of a lemon. Although these do not compare to the drift rates of 0.01degrees per hour achieved by the best INS weapons, such systems cost as little as a few thousand dollars. Such systems currently cannot guide a long-range ballistic missile by themselves, but they have enormous potential as components in an augmented guidance system.

GPS-INS and Kalman Filtering

The developmental philosophy of INS was to create the best possible components. As these operated together, however, their individual weaknesses were exposed, and the level of accuracy achieved amounted to less than the capability of the component parts. A newer approach works synergistically to achieve capabilities significantly better than any of its components could alone. Low-cost, low-accuracy MEMS gyro sets can serve as the core element in a total guidance package that provides continuous updates to correct for their inaccuracies. The result is a low-cost, rugged, and highly accurate system.

Augmented guidance systems rely on a combination of gyro platforms and signals from the satellite-based Global Positioning System (GPS). The resulting GPS-INS can achieve capabilities surpassing the very best INS alone. This method of guidance relies not on any one sensor or set of sensors, but on Kalman filtering. This exploits the powerful synergism between GPS and INS technology, a synergism based on their highly complementary strengths and weaknesses. INS weapons are extremely accurate in the short-term, but errors accumulate over time and rapidly become a serious problem. A GPS is not as inherently accurate, but because its positional readings are continuously recalculated, its errors do not compound with time. Using a Kalman filter, new readings from the GPS essentially are used to correct the drift in the INS. Combining the two systems reduces navigational uncertainties to centimeters or a few meters.

Kalman filtering is an algorithmic process developed in the early 1960s for the systematic elimination of signal errors and integration of multiple guidance signals. It relies on a Covariance Matrix to compare its own estimate of uncertainty against the relative uncertainty of sensor outputs. These are corrected to achieve optimal outputs. The key function of Kalman filtering is to use GPS readings to correct the inherent drift of INS sensors.

Although developments in INS, such as the use of MEMS gyros, have received the most attention, GPS technology has benefited from breakthroughs as well. From its inception in the late 1970s, the GPS was used to aid prelaunch alignment of missile gyros, but the system was too slow for in-flight use.

A new generation of GPS satellites permits much faster signal transmission, while improvements in micro-circuitry have accelerated interpretation of GPS data.

The most famous application of the GPS-INS is the Joint Direct Attack Munition (JDAM), an air-dropped bomb used for the first time in the 1999 Kosovo war. GPS-INS guidance is also increasingly accepted in spacecraft. It is used in the space shuttle and in most civilian and military satellites in low-Earth orbits. The system appears to be used in the U.S. Minuteman ICBM through the Guidance Replacement Program, finalized in 1998 to replace the Minuteman's aging 1970s-vintage Autonetics NS-20 guidance set. It also is available as an option in the newly introduced Russian Iskander (SS-26) ballistic missiles, which have a range of 300 km. RAND Corporation analyses show that the same approach can be used to significantly improve the accuracy of a 1950s-vintage Scud missile with minimal change in equipment. The approach is even easier to apply in cruise missiles.

A major issue for non-American GPS users is the accuracy of the signal. Under the old policy of selective availability, publicly available signals were degraded to 100-meter accuracy. On May 1, 2000, the U.S. Department of Defense (DOD), which controls the GPS network, ceased degrading the quality of the signals available to non-DOD users. With ordinary transceivers, accuracies of 5–10 meters are freely available. In theory, the Defense Department can return to selective availability in time of national emergency. In practice, though, the reliance of commercial users on the undegraded version would make this difficult. Availability will be further guaranteed when the European Galileo, a satellite network virtually identical to the GPS, becomes available around 2010.

What do these changes auger for the future of deterrence and arms control? The increasing availability of GPS-INS technology will make it easier for emerging missile powers to shift from countervalue to counterforce targeting (*see* Counterforce Targeting; Countervalue Targeting). The implications of these developments for the Missile Technology Control Regime have not been fully debated. But it appears likely that the effectiveness of missile technology export controls will significantly decline as a result.

—*Aaron Karp*

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INSTITUTE FOR ADVANCED STUDY

The Institute for Advanced Study (IAS), located in Princeton, New Jersey, is an institution of higher learning and research dedicated to exploring the fundamental mysteries of pure science. It does not offer formal courses, labs, or degrees. Rather, faculty members and fellowship recipients conduct scholarly work without the burden of giving lectures or administering coursework and exams. IAS has no formal ties with any academic institution but does collaborate with other universities, particularly with Princeton University.

IAS was founded in 1930 by an endowment from Louis Bamberger and his sister, Caroline Bamberger Fuld. Abraham Flexner was the first director of the institute. Robert Oppenheimer, also known as the "father of the atomic bomb," was the director of IAS from 1947 until 1966. Albert Einstein became a lifetime member of IAS in 1933 and lived a mile and a half from the institute for the rest of his life.

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School of Historical Studies, and the School of Social Science.

—*Don Gillich*

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Institute for Advanced Study website, http://www.ias.edu.

INTERCONTINENTAL BALLISTIC MISSILES (ICBMS)

The intercontinental ballistic missile (ICBM) provides nations with the ability to destroy targets thousands of miles away. These land-based missiles have ranges in excess of 5,500 kilometers and usually are nuclear armed. Three nations have developed ICBMs: the United States, Russia, and China. The United States maintains two types of silo-based ICBMs. The Russian Strategic Rocket Forces have been in decline since the end of the Cold War. Arms control, aged weapons, and budgetary pressures have forced Russia to reduce its ICBM force, although it still maintains thousands of nuclear-armed warheads to equip hundreds of silo-based, rail-mobile, and road-mobile ICBMs. China's small fleet of ICBMs carries single, high-yield nuclear reentry vehicles (RVs), and China also has a program to develop ICBMs that can carry multiple independently targetable reentry vehicles (MIRVs). Other nations (such as North Korea) have attempted to develop ICBMs.

Defenses against ICBMs and other ballistic missiles are difficult to construct, making them an ideal deterrent weapon because they are a reliable means to deliver nuclear weapons against a variety of targets. Compared to modern long-range bombers or aircraft carriers that might be used in a deterrent role, ICBMs are relatively easy to maintain and operate. For states seeking to develop a credible delivery system for weapons of mass destruction, ICBMs offer a cost-effective way to penetrate an opponent's defenses and strike targets at long ranges.

History and Background

ICBM development began in Germany during World War II. The first operational ballistic missile, the V-2, was a prototype of a longer-range missile that would be capable of striking the United States. This long-range variant of the V-2, called the A-9/A-10, was designed to carry a high-explosive warhead to a target 3,500 miles away. U.S. Navy engineers and scientists believed that the A-10's intended targets were New York and Washington. The Germans

Soviet ICBMs paraded in Red Square on the anniversary of the Bolshevik revolution, 1969. (Jerry Cooke/Corbis) might have been able to launch these attacks as early as 1946. Knowledge gained about the V-2 program and the development of the atomic bomb focused national leadership in the Soviet Union and the United States on the development of ICBMs.

The U.S. Army Air Corps started a series of research programs to investigate the use of ICBMs in 1946. One project, the Consolidated Vultee MX-774, began as a comparison of subsonic cruise missiles and long-range ballistic missiles. The study indicated that ballistic missiles offered a superior delivery system because there were no defenses against ballistic missiles at the time. Subsonic cruise missiles, such as the German V-1, could be defeated by a combination of conventional radar detection, antiaircraft artillery, and relatively slow propeller-driven aircraft. Convair (the renamed Consolidated Vultee firm) continued research on long-range ballistic missiles. Unfortunately, the weight of first-generation atomic bombs in the 1940s was measured in tons, well beyond the payload of the V-2. When the Soviets detonated an atomic bomb on August 19, 1949, however, renewed emphasis was placed on the effort to develop nuclear delivery systems that could reach the Soviet Union. Convair won a contract to develop the first U.S. ICBM, the Atlas. Meanwhile, development of nuclear weapons continued. The first thermonuclear device (the hydrogen bomb) was detonated by the United States on November 1, 1952. Because they produced a relatively high yield for a relatively low weight, thermonuclear weapons were the ideal warhead to mount on the ICBMs under development (*see* Hydrogen Bomb; Thermonuclear Bomb).

After several years of design, development, and testing, the United States deployed the liquid-fueled Atlas ICBM in 1959. The system evolved from a vertical aboveground launch system (gentry tower) to a horizontal aboveground system (coffin launch) and finally to a below ground silo system. Atlas served until 1965. The U.S. Air Force operated Atlas squadrons from California to New York. At one point, the service deployed 72 Atlas F missiles. The Atlas F carried a 4-megaton warhead, and its range was between 6,400 and 9,000 miles. Crews required about 30 minutes to prepare and launch an Atlas.

The U.S. Air Force also developed and deployed the Titan series of ICBMs. Titan development started in 1955. The system was designed as a backup to Atlas and provided the air force with a two-stage, liquid-fueled ICBM that eventually would have a longer range and larger payload than the Atlas. Titan I, which served from 1962 until 1965, had a range of 6,300 miles and could carry a multimegaton nuclear warhead, and its crews needed only 15 minutes to launch their weapon. Titan II had much better performance: With a 9,000-mile range, it could carry a 9-megaton warhead, the largest single warhead ever carried by a U.S. ICBM. Titan II was also more responsive than the Atlas. Crews required only a single minute to launch the missile. Fifty-four Titan IIs defended the nation from 1963 to 1987. Both Titan I and Titan II were silo-based systems.

U.S. Air Force officials, impressed with propellant developments in the 1960s, moved to build a solid-fueled ICBM. Ultimately, the air force would design and deploy three versions of the Minuteman, the first such missile to be built in the United States. Minuteman used a three-stage, solid-fueled rocket motor system and was deployed in underground silos. Minuteman I had a range of 6,300 miles and carried a single reentry vehicle with a 1-megaton yield. This model first went on alert in 1962, and 800 missiles eventually served the country. Minuteman II started to replace the earlier model in 1967. It carried a warhead with a 1.2-megaton yield and had longer range, improved guidance, and penetration aids. Minuteman II served until 1991. A Minuteman III design began in 1964. It had a range of 8,000 miles and carried two to three RVs with a yield of 170 to 375 kilotons. The U.S. Air Force built 500 Minuteman III ICBMs, which continue to serve today.

The Peacekeeper is the latest U.S. ICBM (the single-warhead Midgetman was under development when it was canceled at the end of the Cold War). The Peacekeeper was designed to carry ten RVs, each having a yield of 300 kilotons. Initial air force design efforts concentrated on developing an air- or ground-mobile ICBM to replace the silo-based, and increasingly vulnerable, Minuteman system. Many concepts were tested, and in 1977, air force officials selected a four-stage missile that could be deployed in existing Minuteman silos. The Peacekeeper's range is more than 6,780 miles. The first three stages are solid-fuel systems, and the fourth stage has a liquid-fueled motor. The Peacekeeper was acquired to replace the Minuteman system, but the treaty resulting from the Strategic Arms Limitations Talks

(SALT II) limited the number of ICBMs with multiple RVs. These arms control provisions led to an agreement stipulating that the United States would deploy only fifty Peacekeeper missiles. Peacekeeper is scheduled to be withdrawn from service by 2007.

The Soviet Union also experimented with ICBMs throughout the 1950s. The Soviets introduced their first ICBM, the SS-6 Sapwood (its NATO designation), in 1959. The first truly successful ICBM was the SS-7 Saddler that saw service in 1961. The Soviet Strategic Rocket Forces operated 186 missiles until 1979 when SALT I restrictions forced the Soviets to scrap their SS-7s. This two-stage, liquid-fueled missile had a range of more than 7,100 miles. Soviet missile engineers also employed a similar, less technically sophisticated variant of the SS-7, the SS-8 Sasin. A small number of Sasins served from 1965 to 1977.

Soviet ICBM forces received a boost when they received the SS-9 Scarp, a heavy, two-stage, liquid-fueled system, in 1966. The SS-9 carried the largest nuclear yield of any ballistic missile, a 25-megaton warhead. The missile was also powerful enough to test launch a fractional orbiting bombardment system that would attack the United States from a launch profile that came from the southern hemisphere instead of the shorter northern polar route. This tactic would achieve strategic surprise by avoiding radar and satellite detection.

The Soviet Strategic Rocket Forces continued ICBM development throughout the Cold War. The SS-11 Sego was a liquid-fueled missile that could carry three RVs like the United States' Minuteman III. Soviet solid-fueled ICBMs began being fielded with the two-stage SS-13 Savage, which entered service in 1972. The system stayed on active duty until the end of the Cold War. The Soviets developed and deployed several other ICBMs during the 1970s: the SS-16, SS-17, SS-18, SS-19, and SS-20. These missile developments evolved from silos that were only used once to a design that included a missile in a canister that would limit the damage to the silo, thus allowing multiple uses. Other devices included a "cold launch" that would use a gas generator to push the missile out of the silo before ignition of the missile to allow the silo to escape major damage (*see* Cold Launch). Soviet weapons development also focused on road-mobile missiles that would limit Soviet vulnerability to U.S. missile or aerial strikes. The SS-18 Satan was the largest ICBM fielded by either the United States or the Soviet Union. It could carry a 20-megaton warhead or up to ten smaller RVs.

The SS-24 Scalpel was another Soviet advance. It was a rail-mobile system that began service in 1987. A second version was a silo-based system that carried ten warheads. The last Soviet ICBM was the road-mobile SS-25 Sickle, thought to be designed to survive a nuclear attack and retaliate against American targets. The Russian government has also recently deployed the SS-27. This missile has silo and road-mobile versions that carry countermeasures to defeat a ballistic missile defense system.

The People's Republic of China has fielded two ICBMs, the CSS-3 and CSS-4 liquid-fueled missiles. The CSS-3 is a two-stage weapon that carries a single warhead with a range in excess of 3,400 miles. The CSS-4 has similar characteristics to the CSS-3, but with a range of 8,000 miles.

Technical Details

One of the unique characteristics of the ICBM is its ability to carry a large payload. This capability enables new nuclear weapons states to compensate for relatively inaccurate missiles by means of mounting a warhead with a large nuclear yield atop the missile. However, as technology improves and guidance systems allow for reductions in yield, nations may still opt for the ICBM because it can also carry many light warheads. The missile can carry penetration aids, such as decoys, to help confuse ballistic missile defenses, or a post-boost vehicle to launch several warheads over different trajectories to strike many targets (multiple independently targetable reentry vehicles, or MIRVs). ICBMs that carry more than two RVs are called multiple reentry vehicles.

Current Status and Developing Technologies

The United States possessed 500 Minuteman III and 50 Peacekeeper missiles as of September 20, 2001. Russia, however, still has the largest ICBM force in the world, with about 700 missiles, including SS-18, SS-19, SS-24, SS-25, and SS-27 systems. About half of the force is composed of SS-25 missiles. China has fewer than 45 single-warhead ICBMs but is developing solid-fueled DF-31 road-mobile weapons with an estimated range of 4,500 miles. China has also tested the DF-31A, a mobile missile with a greater range, 7,000 miles. The North Koreans have tested a potential ICBM, in the guise of a space launch vehicle, the Taepo Dong 2, a liquid-fueled, single-warhead delivery vehicle with a range of about 3,400 miles.

Russia, China, North Korea, and Iran are engaged in active programs to improve their ICBM forces. Two emerging threats, China and North Korea, are very focused toward this effort. The Chinese want solid-fueled ICBMs that provide better reliability, quicker reaction, and lower operational costs. The North Koreans have flight-tested many components of the Taepo Dong, which has the range to hit Hawaii and Alaska. Unfortunately, North Korea's past willingness to sell technology and systems may enable many nations to purchase an ICBM capability. Although Iran has not tested an ICBM, it seeks such capability through foreign assistance.

—Clay Chun

See also: Heavy ICBMs; Midgetman ICBMs; Minuteman ICBMs; Missile Defense; Mobile ICBMs; Titan ICBMs

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INTERMEDIATE-RANGE NUCLEAR FORCES (INF) TREATY

The Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Elimination of Their Intermediate-Range and Shorter-Range Missiles—better known as the Intermediate-Range Nuclear Forces (INF) Treaty—was the first arms control agreement to eliminate an entire class of weapon systems (that is, all U.S. and Soviet intermediate-range and shorter-range ballistic and cruise missiles with a range of 500–5,500 kilometers). It was signed in Washington, D.C., on December 8, 1987, by U.S. President Ronald Reagan and Soviet General Secretary Mikhail Gorbachev. The treaty entered into force the following year and called for all treaty-related items to be eliminated within three years. It also provided for an on-site inspection regime that not only promoted confidence on compliance with the treaty provisions but also served as the model for on-site inspections for subsequent arms control agreements. Additionally, the INF Treaty incorporated asymmetric reductions (for example, the Soviet Union was forced to eliminate a significantly larger number of weapon systems than the United States). The INF Treaty comprises the basic treaty, a memorandum of understanding, two protocols, and an annex.

The basic treaty included seventeen articles that defined terms, the types of missiles and support systems covered by the treaty, and verification procedures. Intermediate-range missiles were defined as ground-launched ballistic missiles or ground-launched cruise missiles having a range in excess of 1,000 kilometers but not in excess of 5,500 kilometers. Shorter-range missiles were defined as ground-launched ballistic missiles or ground-launched cruise missiles having a range capability to or in excess of 500 kilometers but not in excess of 1,000 kilometers.

The memorandum, entitled "The Memorandum of Understanding Regarding the Establishment of the Data Base for the Treaty Between the Union of Soviet Socialist Republics and the United States of America on the Elimination of Their Intermediate-Range and Shorter-Range Missiles," contained seven articles. It established the database for the number and location of missiles, launchers, transporters, missile bases, and other support equipment covered by the treaty.

The protocol governing the elimination of weapons included five articles that outlined the missiles and missile-related systems subject to the treaty. The INF Treaty resulted in asymmetric reductions in Soviet and U.S. weapon systems. The United States had an aggregate total number of 859 deployed and nondeployed missiles and 283 deployed and nondeployed launchers included under the treaty. The Soviets had an aggregate total number of 1,752 deployed and nondeployed missiles and 845 deployed and nondeployed launchers included under the treaty.

Several U.S. missile systems were affected by the INF Treaty. The intermediate-range Pershing II ballistic missile, the BGM-109G cruise missile, and the

Mikhail Gorbachev and Ronald Reagan signing the Intermediate-Range Nuclear Forces Treaty, December 8, 1987. (Tim Clary/Bettmann/Corbis)

shorter-range Pershing IA (which was not deployed) all had to be eliminated. In addition, the tested (but nondeployed) Pershing IB missile was included. The treaty also included the Pershing II launcher and launch pad shelter, the BGM-109G cruise missile launch canister and launcher, and the Pershing IA launcher. The Soviet systems covered by the treaty included the intermediate-range SS-20, the SS-4, the SS-5 (which was not deployed), the shorter-range SS-12, and the SS-23. An advanced cruise missile being developed by the U.S.S.R., the SSC-X-4, also was included in the treaty. The SS-20 launch canister, launcher, missile transporter vehicle, and fixed structure for a launcher; the SS-4 missile transporter vehicle, missile erector, launch stand, and propellant tanks; the SS-12 missile launcher and missile transporter vehicle; the SS-23 missile launcher and missile transporter vehicle; and the SSC-X-4 launch canister and launcher were additional Soviet systems that had to be eliminated according to the provisions of the INF Treaty. The INF protocol outlined the specific guidelines and procedures for eliminating each of these treaty-related items.

The protocol on inspections contained eleven articles that outlined inspector responsibilities and guidelines as well as on-site inspection rules and procedures. The protocol limited both parties to 200 inspectors. The inspection regime was more difficult to implement for the United States than for the Soviet Union because U.S. inspectors had more than 130 sites in the Soviet Union, East Germany, and Czechoslovakia to inspect. In contrast, Soviet inspectors had a total of about 30 sites to inspect in the United States, the United Kingdom, West Germany, the Netherlands, Belgium, and Italy. The protocol provided for a number of different types of inspections: base-line inspections (to verify the total number of treaty-related items within the first 90 days of the treaty entering into force); close-out inspections (to verify that a missile facility or base was no longer operational); elimination inspections (to verify that the treaty items were eliminated in accordance with the treaty provisions); and quota inspections (a limited number of short-notice inspections for verifying compliance).

An additional annex on privileges and immunities to be accorded to inspectors and aircrew members granted diplomatic privileges to INF inspectors and flight crews involved in transporting inspection teams in accordance with Articles 29, 30, 31, and 34 of the Vienna Convention on Diplomatic Relations.

The INF Treaty was an important arms control agreement between the United States and the Soviet Union that signaled the beginning of an expanded dialogue between U.S. President Reagan and Soviet leader Gorbachev. The success of the INF Treaty served to bolster confidence in the arms control process and encourage further negotiations to reduce strategic nuclear arms. Thus, the INF Treaty is considered to be a watershed arms control agreement.

—Ken Rogers

See also: Arms Control; Entry into Force; Implementation; North Atlantic Treaty Organization; Verification

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INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA)

The International Atomic Energy Agency (IAEA) is an autonomous organization under the United Nations. Founded in 1957, it promotes and monitors the peaceful uses of atomic energy. Following its statute, the agency seeks "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world" and to "ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose." The IAEA was given an enhanced role in promoting worldwide nuclear safety following accidents at Three Mile Island in Pennsylvania and Chernobyl in the Soviet Union. Over time, the agency's emphasis has shifted away from promoting peaceful uses of nuclear power and toward security concerns such as diversion of atomic material for nuclear proliferation. It has therefore become associated with inspections tied to the 1968 Nuclear Nonproliferation Treaty (NPT) and efforts to prevent proliferation in Iraq and North Korea. The IAEA's mandate to lead global efforts in three areas of atomic energy—peaceful usage, safety, and limitation of proliferation—has proven challenging. IAEA resources are limited, and these three objectives at times conflict. The IAEA has come under increasing criticism in recent years.

President Dwight D. Eisenhower's Atoms for Peace initiative of 1953 was the genesis of the IAEA (*see* Atoms for Peace). Eisenhower joined many scientists and others in suggesting that peaceful uses of atomic energy could play a major role in future human development. The IAEA has a General Conference composed of representatives from all member states. As of 2004, there were 134 member states. The organization also has a thirty-five-member Board of Governors. Some seats on the board are reserved for the ten states most advanced in nuclear technology, and others are elected by the General Conference. The IAEA is financed by a regular budget, dependent on assessments from member states and voluntary contributions to the Technical Cooperation Fund. In 2001, the regular budget was $230 million and voluntary contributions equaled $73 million. The agency's staff consists of just over 2,000 people, and its inspections and monitoring activities are based on more than 225 safeguard agreements in force with 141 states.

One key area of IAEA activity has been oversight of the use of atomic energy in electricity production. Particularly when oil prices rose in the 1960s and 1970s, many saw nuclear energy as a cheap and environmentally friendly alternative to fossil fuels. When the IAEA was founded, there were fewer than twenty nuclear power plants worldwide. In 2000, the IAEA was monitoring 440 reactors that produced 17 percent of the world's electricity. The agency also promotes nuclear power through the international exchange of information, leads many training programs, and publishes manuals that are used globally.

The IAEA has been a leader in other peaceful uses of nuclear technology. In several countries, the agency has led efforts to raise and sterilize male insects such as the tsetse fly using radiation. Upon release these flies cannot mate and therefore gradually reduce insect populations. Elsewhere, trace amounts of isotopes have been added to water supplies so that water management specialists can study water movement and reservoir resupply (*see* Isotopes). Nuclear materials also have been widely used in medical applications. The IAEA maintains its own research laboratories and often works in conjunction with other UN agencies, such as the Food and Agriculture Organization and the World Health Organization.

Since the late 1980s, the IAEA has played a growing role in nuclear safety. The agency has promoted several international conventions on nuclear safety, physical protection of nuclear material, and waste management. It has established international standards for power plants, research reactors, radioactive waste management, and industrial uses of radioactive material. When states need help reaching the standards, the IAEA provides safety reviews and technical assistance.

One of the IAEA's original goals, preventing the diversion of nuclear material to military projects, became much more significant after the 1968 NPT was signed. Non–nuclear weapons states sign "comprehensive safeguard agreements," which cover all declared nuclear material and activities. Nuclear weapons states sign "voluntary offer agreements," which cover only facilities voluntarily submitted by the states, which effectively prohibits monitoring of existing military programs. The IAEA monitors activities by carrying out material accounting and inventory duties, by enforcing containment and surveillance measures at nuclear sites, and by conducting on-site inspections. The agency currently monitors more than 1,000 installations in more than 70 countries.

Some observers have questioned the effectiveness of IAEA monitoring in cases of noncompliant states. These concerns were highlighted and grew more widespread with the IAEA's interactions with both Iraq and North Korea. IAEA inspectors monitored Iraq before the 1991 Gulf War. After the war, however, it became clear that Iraq had a much more extensive nuclear program than was realized, that it had been actively concealing information from the inspectors, and that inspectors at times had checked on and certified parts of complexes that later turned out to contain extensive other facilities. With these problems in mind, new IAEA safeguard agreements were developed that allowed access to all sites, not just those declared by the state, and that focused less on nuclear material accountancy and more on complete assessments of a state's facilities and intentions. The new safeguards and the weight of UN Security Council resolutions on inspections did not end questions of Iraq's compliance, however. Instead, there were twelve post–Gulf War years of disputes between the IAEA and Iraq. At times, the IAEA and the United States also had conflicts over Iraq, such when they disagreed on intelligence assessments and proper tactics for encouraging compliance. This simmering dispute between Iraq and the international community eventually led to the U.S. invasion of Iraq in 2003 as the George W. Bush administration decided to eliminate the Iraqi threat through military action. Ironically, evidence uncovered in the aftermath of the second Gulf War suggested that Iraq had maintained only a rudimentary chemical, biological, and nuclear weapons program (*see* Iraqi Nuclear Forces and Doctrine).

The IAEA has also played a central role in disputes with North Korea. Some analysts see North Korea's removal of IAEA inspectors and monitoring equipment, along with reports that North Korea has built a nuclear weapon, as further proof that the IAEA system only works with countries that already intend to comply. Other observers argue that the strong international reaction in response to these cases of noncompliance show that IAEA goals and inspections have become institutionalized, global norms (*see* North Korean Nuclear Weapons Program).

Iraq, North Korea, and other cases of covert nuclear proliferation also have led some to argue that the IAEA is too cautious and slow. Several former IAEA inspectors became well-known critics of the inspection regime. These criticisms flow from three main institutional limitations. First, as the IAEA depends on states for some intelligence information and for enforcement, it can be greatly affected by states' political calculations and efforts at denial and deception. Second, the IAEA's budget and staffing are small compared to its expanded goals and responsibilities—a problem that may worsen as the IAEA takes on new roles and responsibilities in the war on terrorism. Third, the IAEA's main goals of promoting the spread of nuclear energy, while maintaining tight restrictions to prevent diversion, inherently conflict to some degree.

—John W. Dietrich

See also: Proliferation; Safeguards

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INTRUSIVE VERIFICATION

See Verification

IRANIAN NUCLEAR WEAPONS PROGRAM

The Iranian nuclear program was initiated by Shah Reza Pahlavi in 1957 with the assistance of the United States. Under the auspices of President Dwight D. Eisenhower's Atoms for Peace program, in that year the United States signed a civil nuclear cooperation agreement with Iran (*see* Atoms for Peace). The agreement provided Iran with a 5-megawatt reactor, which came on line in 1967 and has been in continuous operation since that time. The shah established the Atomic Energy Organization of Iran in 1974 and concluded nuclear fuel agreements with the United States, Germany, and France. All U.S. assistance came to an end in 1979, however, when the U.S.-backed shah was ousted from power in a coup that brought the fundamentalist cleric Ayatollah Khomeini to power.

After the revolution, Iran's nuclear program lay dormant until it was revitalized in 1987 by the Ayatollah Khomeini. Since the United States and European governments had halted cooperation in nuclear matters with Iran after the takeover, China became the primary supplier of Iran's nuclear technology and equipment. There also have been reports of assistance provided by Pakistan, India, Argentina, Brazil, and North Korea.

China signed a ten-year scientific nuclear cooperation agreement with Iran in 1990. It supplied Iran with three subcritical and zero-power reactors and a 30-kilowatt thermal research reactor. Assistance from Russia also has played a pivotal role in Iran's nuclear program. Russia and Iran are engaged in a joint project to complete the 1,000-megawatt Bushehr reactor, a project left unfinished by Germany in 1979 and bombed repeatedly during the Iran-Iraq War. Russia is to receive $800 million in exchange for completion of the reactor and instruction in reactor operations, development of uranium mines, and the construction of a gas-centrifuge plant. Russia has attempted to assuage U.S. concerns about the reactor by ensuring that all spent fuel from the plant would be returned to Russia. In addition, the type of commercial nuclear power plant being constructed at Bushehr is poorly suited to plutonium production (*see* Plutonium; Reactor Operations).

Iran does not have a known unsafeguarded reactor capable of producing plutonium. It has purportedly attempted to obtain fissile material on the black market to compensate for its lack of an indigenous capability to produce fissile materials. Iranian scientists, however, may have utilized hot cells obtained from the United States in the 1960s and Argentina in the 1990s to separate significant quantities of plutonium. It is also plausible that Iran may have attempted gas-centrifuge development and laser enrichment using four lasers shipped to Iran in 1978 by the United States.

In February 2003, Iran announced that it had discovered uranium reserves near Yazd, exacerbating concerns about an Iranian nuclear program. Indigenous production of uranium could make the return of spent fuel from Bushehr to Russia largely irrelevant. For its part, Iran stated that it plans to use the uranium extracted from Yazd to fuel its civilian nuclear power program. Iranian officials have insisted that the material will be used only for peaceful purposes and invited the International Atomic Energy Agency (IAEA) to inspect their nuclear facilities. The IAEA has not found any evidence in the past to support accusations of nuclear proliferation in Iran, a member of the Nuclear Nonproliferation Treaty (NPT) since 1970. Iranian officials, however, have resisted pressure to sign enhanced safeguards agreements with the IAEA, known as "93+2 provisions," on the grounds that Iran is being denied civilian nuclear technology for the Bushehr reactor (*see* International Atomic Energy Agency).

Iran is known to have one of the largest ballistic missile programs in the Middle East. Experts have expressed concern that Iran may become a secondary proliferator of missiles and missile technology, in addition to developing longer-range missiles for its own arsenal.

The Iranian missile program has benefited from assistance offered by Russia, China, and North

Korea. Iranian officials have actively backed North Korea's ballistic missile program and reportedly agreed to purchase 150 Nodong-1 missiles from the North Koreans. Iran now possesses approximately 150 Scud-C missiles, up to 200 Scud-B missiles, and an unknown number of indigenous Mushak missiles. It has conducted three tests of the Shahab-3 and deployed the Shahab-4 missile. The Shahab-3 has an 800- to 900-mile range and a payload of 1,650 pounds, while the Shahab-4 has a 1,200-mile range and a 2,200-pound payload. Iran also reportedly is developing the Shahab-5, which would presumably have even greater range and payload capacity than earlier modes. It has stated publicly that the Shahab-4 and Shahab-5 are intended to be space-launch vehicles with no military applications.

—Jacqueline Simon

See also: Iraqi Nuclear Forces and Doctrine; Nonproliferation; Nuclear Nonproliferation Treaty; Rumsfeld Commission

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IRAQI NUCLEAR WEAPONS PROGRAM

Iraq's nuclear weapons program was established in 1988 with the objective of producing a small nuclear arsenal. The program was intended to produce its first weapon by 1991. The destruction of its research and production facilities during the Gulf War virtually eliminated the program. Iraq had a well-funded nuclear program under Saddam Hussein that was intended to develop an indigenous capability to produce fissile nuclear material (highly enriched uranium [HEU] derived from domestic sources), nuclear technology, and nuclear weapons designs. Iraqi scientists and engineers also were hard at work developing various nuclear delivery systems (such as ballistic missiles).

The Iraqi nuclear materials program was divided into seven production and engineering initiatives:

- Research and development of a full range of enrichment technologies to exploit gas enrichment technology;
- Indigenous production and illegal procurement of natural uranium compounds;
- Research and development of irradiated fuel;
- The formation of industrial-scale facilities to produce uranium compounds for fuel fabrication or isotopic enrichment;
- The creation of design and feasibility studies for a local plutonium production reactor;
- Research and development of weapon capabilities for implosion-based nuclear weapons;
- A crash program aimed at safeguarding reactor fuel and recovering HEU for use in nuclear weapons.

In the aftermath of the second Gulf War, the UN Special Commission on Iraq (UNSCOM) was created to verify Iraqi declarations concerning nuclear, chemical, and biological forces by undertaking a series of inspections of declared and undeclared Iraqi weapons facilities and suspected storage sties. Iraqi officials failed to give their complete cooperation to UNSCOM, which resulted in nearly a decade of acrimony that culminated in the second Gulf War that began in 2003. In the aftermath of the second Gulf War, Iraq's nuclear program has been terminated, but the extent of the threat posed by the Iraqi nuclear, chemical, and biological weapons programs remains a source of controversy.

Although as of late 2004 it is impossible to say exactly what Iraqi scientists and engineers were working on, the U.S. and allied intelligence communities apparently began to overestimate the scope and capability of Iraq's programs to develop weapons of mass destruction (WMD) in the aftermath of Operation Desert Fox (1998). This overestimate was in part caused by Iraqi efforts at denial and deception. A consensus formed within intelligence and policymaking communities that Iraqi officials were doing everything in their power to preserve their WMD capabilities and remaining stocks of weapons and to set the stage for a return to production as soon as they could escape UN scrutiny. Saddam Hussein and many of his senior officers apparently believed that they possessed a significant chemical weapons capability, but they never managed to use it in defense of their regime. In the aftermath of the September 11, 2001, terrorist attacks on the United States, the Bush administration was no longer willing to live in a world in which the prospect of Iraq's WMD capability might find its way into the hands of Islamic militants, no matter how farfetched that prospect appeared to critics of the administration. History still must judge whether the Bush administration was correct in ending the Hussein regime, but the war was fought to end the potential threat posed by Iraq's chemical, biological, and nuclear weapons programs.

—Laura Fontaine and James J. Wirtz

See also: Highly Enriched Uranium; International Atomic Energy Agency; Nonproliferation; Nuclear Nonproliferation Treaty; Nuclear Suppliers Group; Payload; Plutonium; Rumsfeld Commission; United Nations Special Commission on Iraq; Uranium

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ISOTOPES

Isotopes are atoms of the same element that have the same number of protons (atomic number) but different numbers of neutrons in the nucleus. Since different isotopes of the same element have different numbers of neutrons, the atomic mass (the sum of the protons and neutrons) is different. Isotopes are denoted by the element name or symbol and the atomic mass number. As an example, uranium has 92 protons in the nucleus. Uranium 238, which has 146 neutrons in the nucleus, and uranium 235, which has 143 neutrons in the nucleus, are examples of uranium isotopes.

An alternative term for isotope is "nuclide." This general term is used to identify any atom that is described by the number of protons and neutrons present in the nucleus.

English chemist Frederick Soddy first hypothesized the existence of atoms of the same element with different atomic masses in 1912, and on February 18, 1913, he coined the term "isotope." The word comes from the Greek term for "at the same place," referring to the fact that the isotopes of a given element are located at the same place on the periodic table (Wikipedia).

British physicist J. J. Thompson discovered the first evidence that isotopes exist in stable elements while experimenting with neon in 1913. He concluded that two different stable forms of neon existed in nature, thereby supporting the existence of isotopes.

Thompson's assistant was chemist Francis W. Aston, who later, in 1918, invented the mass spectrograph. A mass spectrograph is a device that separates electrically charged atoms according to mass and can accurately measure the mass of the atom. From his work with the mass spectrograph between 1918 and 1930, Aston discovered 212 naturally occurring isotopes. He also was able to formulate "the whole-number rule which states that all atomic masses are close to integers and that fractional atomic weights of elements are due to the presence of two or more isotopes, each of which has an approximately integral value" (Parrington et al., p. 3).

Most naturally occurring elements have two or more isotopes; just 20 of the 90 elements that occur in nature have only one isotope. Some isotopes are stable and others are unstable (or radioactive), that is, they may decay into other isotopes or elements. There are 266 stable and 65 unstable naturally occurring isotopes. The latter are also called "radionuclides."

Bombarding certain elements with other particles, for example neutrons, alpha particles, and protons, can create so-called "manmade" isotopes. More than 2,500 isotopes have been produced through such processes. Many of these nuclides are artificially produced radioactive isotopes.

Because two isotopes of the same element are chemically similar, they are difficult to separate. Due to differences in atomic mass, stability, and other physical characteristics, however, isotopes may be separated by several methods. Examples of separation techniques that are used for uranium enrichment, for example, build on this knowledge and include gaseous diffusion, gas centrifuge, electromagnetic separation, and laser isotope separation.

—Don Gillich

See also: Enrichment; Highly Enriched Uranium; Neutrons; Uranium

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ISRAELI NUCLEAR FORCES AND DOCTRINE

After the horrors of the Holocaust, the creation of the State of Israel on May 14, 1948, brought with it existential fears about the survival of the new Jewish state. These fears brought forth the consideration of a nuclear weapons option. With help from the French, the Israelis constructed their own nuclear reactor at Dimona in the Negev desert as a source of fissile material and as a means to establish a nuclear industry. Estimates of how many nuclear weapons Israel has assembled range from 75 up to 400. The nuclear weapons stance that Israel takes is one of ambiguity. It neither confirms nor denies the existence of an Israeli nuclear arsenal.

History and Background

In 1949, the Israel Defense Forces (IDF) Science Corps (known in Hebrew by its acronym, HEMED GIMMEL) conducted a geological survey in the Negev desert to study the potential extraction of uranium reserves. No main source of uranium was found, but researchers discovered that it could be extracted from phosphate deposits. The Israel Atomic Energy Commission (IAEC) was formed in 1952. By 1953, the Science Corps, by then renamed Machon 4, found a way to extract the uranium from the Negev and developed a way to produce heavy water. Possessing these two capabilities provided Israel with the ability to make the nuclear materials most important in creating a nuclear weapon (*see* Heavy Water; Uranium).

Israel had collaborated with France in the construction of a reactor in Marcoule, France, in the early 1950s. When Israel was ready to build its own reactor, it turned to France for help. In 1956, France agreed to give Israel an 18-megawatt research reactor. Due to the Suez Canal crisis, this agreement was never carried out. Instead, on October 3, 1957, France and Israel signed an agreement that committed France to construct a 24-megawatt reactor, in conjunction with an unwritten agreement that France also would build a chemical reprocessing plant. The arrangement was supposed to be carried out in secret and outside the confines of the International Atomic Energy Agency (IAEA) inspections regime. The French went along with Israel's secrecy and provided the materials until May 1960, when France threatened not to supply reactor fuel unless Israel publicized the plant project and agreed to submit to IAEA site inspections. The Israelis soothed French fears, and French contractors finished building the reactor and reprocessing plant. The uranium fuel was also delivered, and the reactor was finished and went critical in 1964.

The United States did not become aware of the Dimona facility until 1958. By December 1960, U.S. intelligence officials realized that Israel was constructing a nuclear facility. Prime Minister David Ben-Gurion had stated that the Dimona facility was a nuclear research center for peaceful purposes. By the mid-1960s, the CIA station in Tel Aviv, Israel, concluded that the Israeli nuclear weapons program was an "irreversible fact."

Current Status

Israeli officials often state that Israel will not be the first state to introduce nuclear weapons into the Middle East. If Israel were to openly declare a nuclear weapons capability, however, the announcement could cause other nuclear powers to grant nuclear guarantees to the Arab states, force the United States to reduce its support of Israel, or force Israel's neighbors to redouble their own efforts to obtain weapons of mass destruction. Since these would all be extraordinarily dangerous developments, Israeli officials will continue to shroud their nuclear programs in ambiguity while quietly maintaining the most capable nuclear arsenal in the Middle East.

In the late 1990s, U.S. intelligence estimated that Israel had 75–130 nuclear weapons, including warheads for its Jericho missiles and bombs for Israeli aircraft. Israel has never tested a nuclear weapon, although many suspect that a 1979 explosion in the southern Indian Ocean was a South African–Israeli joint nuclear test.

—Kimberly L. Kosteff

See also: Nonproliferation; Nuclear Nonproliferation Treaty; Payload; Strategic Forces

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J

JOINT CHIEFS OF STAFF (JCS)

The purpose of the U.S. Joint Chiefs of Staff (JCS) is to advise the president and secretary of defense on military affairs. It includes a chairman, a vice chairman, the chief of staff of the Army, the chief of naval operations, the chief of staff of the Air Force, and the commandant of the Marine Corps. The JCS is assisted in its duties by the Joint Staff, which has no authority in planning or operational matters. The chairman of the Joint Chiefs of Staff is the senior military officer within the U.S. Department of Defense, followed in order by the vice chairman and the other chiefs of staff based on their dates of rank as general.

The JCS is headed by the chairman (or the vice chairman in the chairman's absence), who sets the agenda for the JCS and presides over its meetings. When acting in their capacity as members of the

The Joint Chiefs of Staff includes the heads of the U.S. armed services. Here, the Joint Chiefs meet on November 29, 1949. Left to right: Gen. J. Lawton Collins, U.S. Army; Gen. Hoyt S. Vanderberg, U.S. Air Force; Gen. Omar N. Bradley, Chairman of the Joint Chiefs, and Adm. Forrest P. Sherman, Chief of Naval Operations. (National Archives)

Joint Chiefs of Staff, they are supposed to serve primarily as military advisers to senior elected officials, not just as the chiefs of their respective military services. The chairman of the Joint Chiefs of Staff is the principal military adviser to the president, the secretary of defense, and the National Security Council (NSC). All JCS members are by law military advisers, however, and they may respond to any request for information or advice they receive or voluntarily submit, through the chairman, advice to the president, the secretary of defense, or the NSC.

Over time, the executive authority of the Joint Chiefs of Staff has evolved. In World War II, the joint chiefs acted as executive agents in dealing with theater and area commanders. With the passage of the National Security Act of 1947, their role shifted and they became planners and advisers to the president and secretary of defense rather than commanders of combatant commands. Nevertheless, under the 1948 Key West Agreement, the joint chiefs served as executive agents for unified commands, a responsibility that allowed the service component executive agent (who provided logistical and administrative support to the combatant commands) to originate direct communication with the combatant command. Congress abolished this authority in a 1953 amendment to the National Security Act. Today, as a result of the Goldwater-Nichols DOD Reorganizations Act of 1986, the JCS has no authority to command combatant forces. Their role now is to serve as military advisers to the highest levels of the U.S. government.

—Guy Roberts

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JOINT DECLARATION ON DENUCLEARIZATION OF THE KOREAN PENINSULA

Signed on January 20, 1992, by the prime minister of the Republic of Korea (ROK, or South Korea) and representatives of the Democratic People's Republic of Korea (DPRK, or North Korea), the Joint Declaration on the Denuclearization of the Korean Peninsula sought to limit the danger of nuclear conflict in the region by eliminating nuclear weapons from the Korean peninsula. The six-point agreement came into force on February 19, 1992.

In the agreement, both countries pledged not to test, produce, receive, possess, store, deploy, or use nuclear weapons. The agreement sought to regulate the use of nuclear energy to ensure that it was used for peaceful purposes and not for reprocessing or uranium enrichment. It also created a South-North Joint Nuclear Control Commission to implement an inspection regime in order to monitor compliance with the agreement.

The commission's activities, however, have been placed on hold since 1993 because the parties have been unable to agree on the terms of a reciprocal inspection regime. No inspections have been conducted under the terms of the agreement. This failure was overshadowed by the 1994 Agreed Framework, in which North Korea pledged to implement the terms of the Joint Declaration and engage in North-South dialogue.

The Joint Declaration has subsequently become part of a wider diplomatic dispute between the DPRK and the United States. At almost regular intervals, tensions peak on the Korean peninsula as the regime in Pyongyang makes veiled and not so veiled threats about the DPRK's nuclear capabilities and intentions, much to the consternation of the international community. In December 2003, for example, North Korea openly claimed to have several operational nuclear warheads.

—J. Simon Rofe

See also: North Korean Nuclear Weapons Program; South Korean Nuclear Weapons Program

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K

KILOTON

A kiloton is a measure of the energy released during a nuclear detonation. A 1-kiloton blast is equal to an explosion of 1,000 tons of trinitrotoluene (TNT), a high explosive. This definition refers to all of the energy released by a weapon, regardless of the form. When a nuclear explosion occurs, only a small part of the released energy is in the form of explosive energy—other types of energy released include heat, pressure, thermal energy, and radiation. A chemical explosion, in contrast, mostly takes the form of blast. The Hiroshima explosion was estimated to be 12–18 kilotons, for example.

—Zach Becker

See also: Fission Weapons; Megaton

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KWAJALEIN ATOLL

Kwajalein Atoll is part of the Marshall Islands, which were wrested from the Japanese in February 1944, during World War II. The world's largest coral atoll, it lies east of the Philippines and northeast of New Guinea in the South Pacific Ocean.

Kwajalein consists of 97 islands, comprising 6.5 square miles that surround a 1,100 square mile lagoon. At the end of the war, it served as a refueling stop for the B-29s en route to the atomic bombing missions in Japan. During the Korean and Vietnam wars, Kwajalein served as a refueling stop for cargo and personnel transports.

Between 1958 and 1963, Vandenberg Air Force Base, California, and a Kwajalein test facility were built to allow Atlas, Minuteman, and Titan rockets to be launched from the United States, and Nike-Zeus rockets, and later Spartan missiles, to intercept them over the Pacific. The first successful interception occurred in 1962. In the 1970s, the Homing Overlay Experiment (HOE) demonstrated that incoming missiles could be destroyed while they were outside the Earth's atmosphere without using nuclear warheads. The successful HOE system was the cornerstone of the Ronald Reagan administration's Strategic Defense Initiative (*see* Strategic Defense Initiative [SDI]). By the 1990s, facilities on Kwajalein were participating in space tracking missions and other space operations.

Kwajalein lagoon serves as the splashdown point for intercontinental ballistic missiles fired from Vandenberg AFB some 4,200 miles away. About 3,000 Americans connected with the test site live on the islands.

—Frannie Edwards

See also: Bikini Island Missile Defense; Strategic Defense Initiative

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L

LAUNCH ON WARNING/ LAUNCH UNDER ATTACK

An increase in prompt hard-target kill capability in the 1980s appeared to enable the Soviet Union to destroy much of the U.S. land-based strategic capability as well as its command and control centers. This development forced U.S. nuclear planners to consider adopting a launch-on-warning or launch-under-attack posture for U.S. strategic deterrent forces. A launch-on-warning policy would stipulate that strategic nuclear forces would be launched upon detection of an enemy attack, before the ultimate confirmation of a nuclear attack—explosions on U.S. territory—occurred. A launch-under-attack policy would set in place the ability to launch nuclear forces only after nuclear weapons had begun detonating over their targets.

To make a launch-on-warning posture a reality, effective early warning systems and a responsive national command authority must be available in peacetime and in crisis. Following deployment of Defense Support Program satellites in 1971, U.S. policymakers could expect about 30 minutes of warning from the moment of a Soviet intercontinental ballistic missile (ICBM) launch to its impact on U.S. territory. Soviet submarines equipped with submarine-launched ballistic missiles (SLBMs) posed the threat of reducing potential reaction times. If deployed near the coastline of the United States, submarines could launch their SLBMs on depressed trajectories, thereby reducing missile flight times to U.S. cities and strategic bases to a matter of minutes. Under these circumstances, a launch-on-warning policy was highly demanding: When on day-to-day alert, early warning, presidential launch authority, and launch orders would have to be generated in a matter of minutes to avoid a decapitating attack. Furthermore, the president would have to make the decision to use nuclear weapons while being evacuated by helicopter to the E-4B National Airborne Operations Center (NAOC), hopefully located somewhere outside the lethal blast radius of weapons targeted against Washington, D.C. Because of the significant challenges involved in alerting the appropriate parties, making crucial decisions, and releasing launch authority under compressed time periods, launch authority would likely be predelegated further down the chain of command. The risk of inadvertent or accidental nuclear war would be high.

The launch-under-attack posture clearly minimizes the risks of inadvertent or accidental nuclear war. However, it demands highly survivable retaliatory forces, such as road- or rail-mobile ICBMs as well as mobile, hardened command and control systems able to function effectively throughout a nuclear attack. Predelegation of launch authority is still a key component of a launch-under-attack strategy because of the assumption that the national command authority would be one of the first targets struck by an opponent.

—Malcolm Davis

See also: Cheyenne Mountain, Colorado; Command and Control; Ride Out

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LAUNCHERS

A missile launcher is a vehicle or fixed structure that serves as a firing position for a ballistic missile. Launchers must be capable of storing a missile in a ready launch status for extended periods of time, protecting it from the elements and keeping it secure from unauthorized destruction and direct attack by an opponent (*see* Intercontinental Ballistic Missiles).

Land-mobile missiles are often carried on vehicles called transporter-erector-launchers (TELs). TELs can be sophisticated, tracked vehicles that carry missiles in a horizontal cradle over rough terrain or roads, or they can be simple conversions of commercially available trucks that have little cross-country capability. Once a TEL leaves its garrison, it generally hides in the countryside, under culverts, bridges, or in rugged terrain that provides some overhead cover, and then moves into a pre-surveyed firing position to launch its missile. The missile is then raised into a vertical firing position. Simple TELs can be destroyed once they give away their position as a result of firing the missile, but more sophisticated TELs and other support vehicles associated with the missile launch generally "scoot" to another predetermined hiding position to avoid counter battery fire. Missiles also can be deployed on railroad cars. These rail-based launch cars work like TELs in that they carry the missile in a horizontal position and then move to pre-surveyed launch sites to erect and fire the missiles. Because of the great weight of intercontinental ballistic missiles, rail-mobile systems offer advantages over land-mobile systems. The cars, camouflaged to appear as much as possible like a normal train, can be shuttled across large areas, making it difficult to detect and attack them.

Fixed-site launchers initially were simple steel and concrete structures that provided a level and stable platform to raise, fuel, and fire a missile. These surface structures, however, were easily detectable from the air and were relatively fragile, making the missiles an easy target. These launch tables also exposed the missiles to the elements, increasing maintenance problems and reducing the amount of time a missile could be placed on alert. To solve these problems, most later missiles were placed in underground missile "silos," steel-reinforced concrete structures that created a controlled environment for the missiles. These silos also could be hardened to withstand extraordinarily high amounts of blast overpressure, which forced opponents to develop accurate delivery systems to attack them with relatively large nuclear warheads. Silos were connected to launch control officers located at remote underground command "capsules."

Most missile silos were designed for "hot launch," that is, the missile silo door would be blown off by explosive charges, and the missile would ignite in the silo and then fly to its target. Hot launch would destroy the silo, however. The Soviet Strategic Rocket Forces experimented with "cold launch" systems in which the missiles would be ejected from the silo by a compressed gas, for example, and ignite only after clearing the launcher. This raised the possibility that Soviet missile silos might have been capable of reloading, although many believed that it was unlikely that personnel could regain access to missile fields that had been subjected to nuclear attack or that missile silos that had been attacked would remain functional (*see* Cold Launch; Silo Basing).

Submarines that carry ballistic missiles are generally equipped with launch tubes that allow the submarine to fire its missiles under water. The missile is expelled from the launch tube using pressurized gas and ignites after clearing the surface. If ignited inside the submarine, missiles would quickly burn a hole through the hull. Submarines must be equipped with sophisticated navigation and buoyancy systems to launch missiles while submerged. Knowledge of the exact launch position is a key requirement for missile accuracy. The submarine also must remain at a constant depth and angle during the launch process, a challenge given the tons of seawater that rushes into the missile tube after the missile is shot to the surface (*see* Submarines, Nuclear-Powered Ballistic Missile [SSBNs]).

—James J. Wirtz

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LAWRENCE LIVERMORE NATIONAL LABORATORY

Operated under a contract with the University of California Board of Regents, Lawrence Livermore National Laboratory (LLNL), a 12-square-mile U.S. Department of Energy facility, conducts research and development activities associated with all phases of the nuclear weapons life-cycle as well as research on nonproliferation, arms control, and treaty verification technology. Facilities include the High Explosive Application Facility (HEAF); a tritium facility; the NOVA laser used for Inertial Confinement Fusion (ICF) research; and the Atomic Vapor Laser Isotope Separation (AVLIS) plant. The National Ignition Facility (NIF), a new ICF laser facility, is under construction at the laboratory. Lawrence Livermore employs about 7,800 people.

Following the Soviet Union's first atomic explosion in August 1949, Ernest O. Lawrence, the director of what was then called the University of California Radiation Laboratory (UCRL), voiced his grave concerns about the possibility that the Soviets would quickly proceed with the development of the hydrogen (fusion) bomb. Sharing this worry was Edward Teller, who had worked at the Los Alamos Laboratory during the war, and who had, in 1949, headed the project there that was exploring the possibility of producing a thermonuclear device. Lawrence and Teller, sharing a passion for science and a dedication to the United States, wanted to respond to those uncertain times in a direct and useful way that would ensure America's supremacy in the field of nuclear weapons. They met in October 1949 to discuss their concerns about the Soviet atomic program. Teller believed that friendly competition for Los Alamos—the only weapons laboratory in the United States at the time—would accelerate the development of thermonuclear weapons and fuel scientific accomplishments. In June 1952, at an abandoned Naval Air Station in Livermore, California, a branch of the UCRL was created.

Most nuclear warheads that have entered the stockpile since 1960 have benefited from the scientific competition between Los Alamos and Lawrence Livermore. Several are still in the arsenal. The B83, designed by LLNL, is an Air Force gravity bomb intended to be delivered in low-level flight against "hardened" targets (concrete missile silos and command and control centers). First deployed in 1983, it has a high yield (somewhere between 1 and 2 megatons). As many as 950 of these weapons may be in the U.S. arsenal. The W87 warhead was designed by LLNL for the Air Force's Peacekeeper intercontinental ballistic missile. It was first deployed in 1986, and 500 W87s remain in the arsenal.

Its proximity to Silicon Valley also helped Lawrence Livermore to become the center of computer-simulated nuclear explosion modeling. After the completion of Comprehensive Test Ban Treaty negotiations in 1996, the laboratory instituted an accelerated strategic computing initiative designed to ensure that verification requirements could be met by the time the treaty entered into force. (The U.S. Senate considered the treaty in 1999 but has not yet ratified it.) The shift relied on computer simulation to obtain more accurate modeling data and valid computer code predictions of fission and fusion reactions to compensate for prohibitions on testing actual devices. Massive parallel processing utilizing the world's premier supercomputers allow for complex modeling and data collection. For example, in the field of computational fluid dynamics, the turbulent fluid flow of high ionization states of radioactive elements may be modeled and three-dimensional flow modeling and spatial dimensional calculations are possible. Weapon design effects and fusion energy production can also be modeled. Today, Lawrence Livermore, along with the other national laboratories, runs a nuclear stockpile stewardship program to guarantee the reliability and safety of the U.S. nuclear weapons stockpile.

—*Gilles Van Nederveen*

See also: Los Alamos National Laboratory; Sandia National Laboratories; Stockpile Stewardship Program

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Lawrence Livermore websites, http://www.llnl.gov and http://www.education.llnl.gov.

LAYERED DEFENSE

See Missile Defense

LEAKAGE

See Missile Defense

LIGHT-WATER REACTORS

The most widely used nuclear reactor in the world today is the light-water reactor. In these reactors, water acts as both moderator and coolant; that is, fission neutrons are moderated (slowed down) and heat is transferred to the water. The two principal designs for light-water reactors are the boiling-water reactor (BWR) and the pressurized-water reactor (PWR). In BWRs, the water is allowed to boil in the reactor core, and the steam is used to drive a turbine generator to create electricity. In PWRs, the water is under higher pressure and does not boil; however, this water goes to a steam generator where heat is transferred from the primary loop to another water loop (or secondary loop) at a lower pressure, producing steam, which drives a turbine generator to create electricity (*see* Pressurized-Water Reactors [PWRs]; Reactor Operations).

History and Background

Over sixty years ago, on December 2, 1942, the world's first self-sustaining nuclear chain reaction took place on a squash court beneath Stagg Field on the campus of the University of Chicago in an experiment led by Manhattan Project scientist Enrico Fermi (*see* Manhattan Project). The age of nuclear power had begun. By the end of World War II, the U.S. Navy believed it was possible to develop a nuclear propulsion program for its ships. The first light-water reactor designed for nuclear propulsion followed on the work of Admiral Hyram Rickover in the 1940s and 1950s. After spending some time at the Oak Ridge National Laboratory in 1946, Rickover was convinced that a sufficient technological base was available, and Westinghouse received a contract to build a light-water prototype reactor for submarines. This prototype, known as the Mark I, was tested in early 1953, and its successor, the Mark II, was installed in the submarine *Nautilus.* The *Nautilus* was launched in early 1954 and had no major problems in its sea trials. The performance of the first two nuclear reactors signified that light-water reactors were a viable power source.

At the 1955 Peaceful Uses of the Atom Conference in Geneva, the light-water reactor was selected as the type of reactor that could best fill the energy needs of the future. Although the first commercial reactor to be connected to a power grid was the gas-graphite reactor at Calder Hall in the United Kingdom in August 1956, the second one to be connected to a power grid was a light-water reactor at Shippingport, Pennsylvania, in December 1957 (*see* Gas-Graphite Reactors). Under the 1958 Euratom Accord and the 1954 Atoms for Peace Program, light-water reactors were introduced to Europe and were quickly accepted by those countries not having indigenous reactor programs (*see* Atoms for Peace; Three Mile Island).

In the 1950s and 1960s, the U.S. Atomic Energy Commission investigated a variety of commercial power-reactor designs, carrying several to the prototype stage. Westinghouse and General Electric were at the forefront of developing light-water reactors for domestic commercial use and export. Westinghouse, which developed the light-water reactor for U.S. Navy propulsion systems, continued to market the PWR. General Electric, which had developed an unsuccessful liquid metal–cooled type of reactor for the navy, marketed BWR reactors. In the early 1960s, light-water reactors began to enter commercial service. About 80 percent of all the nuclear power plants built or under construction in the world today are light-water reactors.

Technical Details

The prompt fission neutrons (that is, those neutrons emitted immediately from the fission process) created in fission reactions are high-energy (fast) neutrons. Fissile isotopes such as uranium 235 (U-235) and plutonium 239 (Pu-239) have a very low probability of undergoing fission with the absorption of fast neutrons; consequently, these fast neutrons must be moderated (slowed down) to sustain fission reactions. The fissile isotopes have a much higher probability of undergoing fission with low-energy (thermal) neutrons. The parameter used to describe this probability of fission interaction is called the "microscopic fission cross-section." For example, the microscopic fission cross-section of U-235 for thermal neutrons is approximately 420 times greater than for fast neutrons.

The primary mechanism by which fast neutrons are slowed down is through elastic scattering. Consider the collision between two identical billiard balls where one ball is stationary and is hit head-on by a moving billiard ball. After the collision, the moving ball will become stationary and the stationary ball will then move off with the same speed as the incident ball before the collision. In this example of an ideal elastic collision, the moving ball gives all of its energy to the stationary ball. Now assume the same moving billiard ball has a collision with a stationary bowling ball. Upon colliding, the billiard ball will bounce off with very little change in speed (and energy). The relative mass of the particles in the collision are important in determining how much energy the colliding particle will lose during each collision. These examples are analogous to what is happening in light-water reactors. The fission neutrons undergo elastic collisions with light water, or regular H_2O, which is made primarily of hydrogen. The hydrogen nucleus is approximately the same mass as the neutron; consequently, the neutron loses relatively large amounts of energy during every collision. If the moderator were a material with a much more massive nucleus, the fission neutrons would require many more collisions in order to slow down, since they would not lose nearly as much energy per collision.

In a light-water reactor, the water serves a dual purpose as both the moderator and the coolant. The heat from fission comes from approximately 200 mega electronvolts (MeVs) of recoverable energy from each fission event. This heat energy comes primarily from the kinetic energy (the energy of motion) of the fission products emitted by each fission event. The heat transferred from the fuel to the water heats the water to high temperatures. If the reactor is a PWR, the high pressure will ensure that the water remains in liquid form. The hot water in the PWR goes through a steam generator that uses conduction to heat the water in a secondary loop to high temperatures. The water in this secondary loop is at a much lower pressure, which allows the water to become steam. BWRs operate at a lower pressure in the reactor; consequently, the water boils in the upper portion of the reactor. It is the steam from these reactors that drives the turbine blades (*see* Isotopes; Plutonium; Uranium).

Development of Future Technologies

The design and implementation of nuclear reactors has progressed from very simple "proof of concept" designs to the complex machines of today. One way that scientists and engineers describe the evolution of these reactors is by categorizing them in groups. Each group of reactors is characterized by the performance standards it meets and the technological advances it utilizes, referred to in terms of "technological generations," or "Gen." The first demonstration reactors were classified as Gen-I reactors. The Gen-II reactors are mostly of the BWR and PWR type and are used today throughout the world. In 1996, Japan and a few other nations began producing power with Gen-III reactors, also called "advanced reactors." These reactors are evolutionary rather than revolutionary and are based upon safer, more robust, proliferation-resistant designs and proven concepts. In all likelihood, the next group of reactors built in the United States will be Gen-III+ reactors that will utilize the experience gained in building the Gen-III reactors to produce a more refined version of the light-water reactor. The future of reactor technology is wide open. Some concepts will be evolutionary designs based upon existing technology; others may be radical departures from current designs. This class of future reactors, which may be under construction as early as approximately 2025, is collectively known as Gen-IV.

—*Edward P. Naessens, Jr.*

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LIMITED NUCLEAR WAR

Limited nuclear war is a situation in which two or more states use nuclear weapons in an armed conflict but do not attempt to annihilate their enemies by striking massively at the other side's urban-industrial targets. In a limited nuclear war, nuclear weapons would be used on one or more elements of a nation's land-based nuclear infrastructure or other critical military, industrial, logistical, or command and control centers. The purpose of a limited nuclear attack could be to create military paralysis, to destroy a single sector of the adversary's economy, or to simply demonstrate the attacker's resolve and willingness to employ nuclear weapons in the conflict.

The state that attempts to fight a limited nuclear war presupposes that a limited nuclear attack would seriously damage its opponent's military infrastructure while causing a relatively low level of civilian deaths. This is to ensure that, while a state's ability to fully retaliate is paralyzed, its population will not immediately demand a full-scale nuclear response. The attacking state anticipates that the civilian population will hope to end hostilities and assent to the demands of the attacker to avoid a large-scale attack.

The ultimate purpose of limited nuclear war is both political and military. In a military sense, the goal is to affect the course of the war in one's favor. The political objective is to raise the prospect of a full-scale nuclear exchange in the mind of the opponent, thereby bringing about a rapid termination of hostilities. The limited nuclear war doctrine was put forward in the 1960s by security analysts such as Robert Osgood in response to the Soviet Union's acquisition of a credible nuclear capability. To make the threat of nuclear weapons use more credible while devising options for something less than a full-scale nuclear attack that would make mutual nuclear annihilation likely, policymakers sought a flexible nuclear doctrine that would not necessarily result in escalation to all-out nuclear war. Technological advances that produced small, relatively low-yield, accurate nuclear weapons led some strategists to believe that it might be possible to fine-tune nuclear strikes and limit the scope and destructiveness of nuclear war.

Secretary of Defense James Schlesinger announced in 1974 that the United States had adopted the concept of limited nuclear war as part of U.S. strategic doctrine. This decision was in part due to the overwhelming destructive power of both sides' nuclear arsenals. As the destructive capability of the superpowers' nuclear arsenals increased, it became clear that an all-out nuclear confrontation between the United States and the Soviet Union would lead to unprecedented devastation and the death of hundreds of millions of people. A lack of options in doctrine and capabilities increased the possibility that a conflict over peripheral issues could escalate into an all-out nuclear war. By adopting a limited nuclear warfighting doctrine, the United States was able to tailor its response to the requirements of the situation. Although some saw limited nuclear options as a way to reestablish deterrence after it had failed to prevent the outbreak of conventional war, others saw limited nuclear options as a way to actually fight and win a nuclear war between the United States and the Soviet Union.

The controversy surrounding the adoption of the limited nuclear war doctrine was centered on the attacking state's ability to control the situation. Counting on one's ability to destroy the enemy's will to fight, if not its retaliatory capability, is a significant gamble. Since nuclear war is a zero-sum game, and all states want to retain control and legitimacy, many analysts believe that limited nuclear war doctrine is insanely risky and places too much faith on the attacker's ability to predict and control its enemy's response.

Following the end of the Cold War, smaller nuclear powers have also adopted limited nuclear war doctrines because of their limited nuclear capabilities and the limited threats they face. India has publicly announced its adoption of the doctrine, for example, not only to prepare the public for the demands, albeit limited, that such a war would entail, but also to send a message to Pakistan that India would not rely on nuclear weapons alone in a conflict but would also bring its conventional military superiority to bear.

—*Abe Denmark*

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LIMITED TEST BAN TREATY (LTBT)

The Limited Test Ban Treaty (LTBT), signed originally by the United States, England, and the Soviet Union in August 1963, prohibits nuclear explosions in the atmosphere, under water, in outer space, or in any other environment if the explosion would cause radioactive debris to be present outside the border of the state conducting the explosion. The LTBT's signing followed years of negotiations on a comprehensive nuclear test ban that had been slowed primarily by disputes over verification of underground tests (*see* Verification). Once the countries agreed to set aside the underground testing issue, the treaty was negotiated in a matter of weeks. It also was quickly ratified by a vote of 80–19 in the U.S. Senate and came into force in October 1963. The treaty later was opened to other signatories, and more than 100 countries have now signed. France and China remain formally outside of the treaty but have pledged to adhere to its restrictions. The treaty has helped to protect the global environment from further contamination from radioactive fallout.

Attempts to negotiate an international nuclear test ban began in 1955. In addition to disputes over underground testing, the attempts were complicated by both U.S. and Soviet efforts to link the test ban to broader arms control measures unacceptable to the other side. Support for a ban grew in both public and government circles as surveys showed increasing global radioactive fallout levels. Scientists warned of possible genetic defects and higher cancer rates, and several accidents exposed civilians to high levels of fallout (*see* Fallout; Radiation). The Cuban missile crisis then gave new impetus to arms control efforts and increased the personal efforts of President John F. Kennedy and Soviet Premier Nikita Khrushchev to find ways to reduce tensions and the risk of nuclear war between the superpowers (*see* Cuban Missile Crisis).

The 1963 negotiations centered on atmospheric, water, and space tests. These tests could be verified with existing capabilities and therefore required neither the creation of a new international monitoring agency nor onsite inspections. Additionally, these types of tests were presumed to be causing the worst fallout, so banning them would produce the greatest benefit for the environment. The treaty's terms prohibit all nuclear explosions, not just tests, to prevent any disputes over peaceful explosions versus weapons testing. The treaty is of unlimited duration, although parties can withdraw with three months' notice if they decide that extraordinary events related to the subject matter of the treaty have jeopardized the supreme interests of their country. Also, amendments can be added if they are approved by a majority of the parties and the three original parties.

In arguing for ratification of the LTBT, President Kennedy suggested it could affect the world in four ways. First, he claimed that it could reduce world tension and encourage further agreements. The LTBT was the first major international nuclear arms control agreement, and it set a precedent that helped lead to later arms control agreements and détente. Second, the president argued it could reduce radioactive fallout globally. Despite some atmospheric testing by nonsignatories, fallout levels returned to the level of natural background radiation within ten years after LTBT went into effect. Third, Kennedy suggested the LTBT could help limit the proliferation of nuclear weapons. The treaty's impact here is questionable, and certainly it did not prevent proliferation. Fourth, Kennedy argued that the treaty would have a major "braking effect" on the arms race. Instead, both superpowers continued to develop more weapons with greater yields and technical sophistication by simply relying on underground testing. The LTBT itself called for a comprehensive test ban in the future to stop underground tests. A Comprehensive Test Ban Treaty (CTBT) was signed in 1996, but the United States has so far refused to ratify such a treaty. Thus, the LTBT has had mixed results in achieving Kennedy's vision.

—John W. Dietrich

See also: Arms Control; Détente; Nuclear Test Ban; Underground Testing

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LITHIUM

Lithium (Li) is a low-density metal. It has three protons in its nucleus. With a density only about half that of water, it is the lightest of all metals. It does not occur freely in nature; in compounds, it is found in small units in nearly all igneous rocks and in the waters of mineral springs. The metal has the highest specific heat of any solid element. Lithium is currently recovered in Searles Lake, California, and in Nevada and North Carolina. Since World War II, the production of lithium metal and its compounds has increased. Lithium is often used in heat transfer applications. It is highly corrosive, however, and requires special handling.

Lithium 6 (Li-6), an isotope, has two nuclear weapons applications: as a reactor target and control rod material for the production of tritium, and as a thermonuclear weapons material. In both cases, tritium is produced by means of a neutron absorption process. Li-6 is a critical material for the manufacture of dry thermonuclear devices that do not require the use of liquid deuterium and tritium as boosters. Li-6 has the special property of being readily transformed into helium 4 and tritium when its nucleus is struck by a neutron. To produce a thermonuclear device, lithium is combined with deuterium to form the compound lithium-6 deuteride. Neutrons from a fission (primary) device bombard the lithium in the compound, liberating tritium that fuses with the deuterium. The alpha particles are electrically charged and at a higher temperature contribute directly to forming the nuclear fireball (*see* Deuterium; Isotopes; Hydrogen Bomb; Tritium).

Lithium enriched in the isotope Li-6 is most often separated from natural lithium by the column-exchange electrochemical process, which exploits the fact that Li-6 has a greater affinity for mercury than does Li-7. A lithium-mercury amalgam is first prepared using the natural material. The amalgam is then agitated with a lithium hydroxide solution, which also is prepared from natural lithium. The desired Li-6 concentrates in the amalgam, and the more common Li-7 migrates to the hydroxide. A counterflow of amalgam and hydroxide passes through a cascade of stages until the desired enrichment in Li-6 is achieved.

The containment vessel of a thermonuclear device is cylindrical, but it is rounded at the end where the plutonium (Pu) implosion device (called the "primary") sits. This design helps to scatter the X-ray flash down the tube. The containment vessel is made of some thick, dense metal, such as uranium 238 (U-238). The fusion fuel capsules are also cylindrical and are mounted in polystyrene foam (better known by its Dow Chemical Company trade name, Styrofoam). The fuel capsules are surrounded by a blanket of U-238 (or U-235). This blanket acts as a radiation shield on the side of the capsules facing the primary. Fusion fuels often consist of lithium-6 deuteride and possibly some lithium-6 tritide. These are chemically stable solid compounds of lithium with deuterium and tritium, respectively. This reaction provides additional tritium for the fusion reaction.

As the implosion process begins, the X-rays from the primary rapidly burn down through the polystyrene foam, creating a high-pressure plasma, which compresses the first fuel capsule in a cylindrical implosion. However, the fuel is still not hot enough to undergo fusion. This is where the second major design innovation comes in. A cylindrical rod of either U-235 or Pu-239 is located on the axis of the fuel capsule and arranged so that the cylindrical implosion will cause it to become supercritical. A small aperture in the radiation shield allows neutrons from the primary to initiate a chain reaction in the rod, which then supplies neutrons to transmute the lithium into helium and tritium and supply the extra energy required to spark off the fusion reaction. Using an analogy drawn from the way fuel is ignited in a car engine, this rod is called the "spark plug" by nuclear weapon designers. The very high-energy neutrons released by the fusion reaction are capable of inducing additional fissions in the U-238 blanket and the confinement casing. Each individual fission produces more than ten times the energy of the previous fusion; thus these tertiary fissions can significantly augment the yield of the weapon. It is possible to extend the yield of the device to virtually any desired value by adding additional fusion capsules (*see* Plutonium; Thermonuclear Bomb; Uranium).

Like the U.S. program, the Soviet thermonuclear program initially focused on igniting nonequilibrium detonation in liquid deuterium (a scheme eventually shown to be impractical, if not impossible). And like American scientists, the Soviets had tried to amplify the yield of a fission bomb by igniting a limited fusion reaction in a lithium-6 deuteride blanket. Unlike the Americans, however, the Soviets turned this idea into a deliverable weapon. The detonation of the RDS-6s device in the fifth Soviet nuclear test (dubbed "Joe 4" in the West) used fusion in a practical weapons design. Not a "true" hydrogen bomb, this device obtained nearly its entire yield from fission and was limited for practical purposes to yields of less than 1 megaton. It was never widely deployed.

The RDS-6s used a U-235 fissile core surrounded by alternating layers of fusion fuel ((lithium-6 deuteride spiked with tritium) and fusion tamper (natural uranium) inside a high-explosive implosion system. The small U-235 fission bomb (about 40 kilotons) acted as the trigger. The total yield was 400 kilotons. Fifteen to 20 percent of the energy was released by fusion, and 90 percent was produced by the fusion reaction.

—Gilles Van Nederveen

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LITTLE BOY

On August 6, 1945, the first atomic weapon, named "Little Boy," was released from the U.S. bomber *Enola Gay* over the Japanese city of Hiroshima. The resulting devastation, as well as the devastation of Nagasaki by a second bomb named "Fat Man" three days later, has been credited with hastening the end of the war with Japan. Little Boy's uranium-fueled, gun-type design was a simple first-generation weapon that is likely to be duplicated by nations or nonstate actors that want to acquire a nuclear device.

The casing of the gun-type design resembles a cannon. Rings of uranium 235 (U-235) were placed at the muzzle, and a cylindrical-shaped mass of U-235 was placed at the other end in front of a conventional explosive. The simplicity of Little Boy's gun-type design meant that designers had high confidence that it would work without being tested. Because uranium was in short supply, the design was not tested prior to the destruction of Hiroshima.

Little Boy was dropped from the *Enola Gay* with the fuse set to explode at a specific altitude above the ground to maximize its destructive force. When the barometric sensors recorded a specific air pressure (that is, altitude), the conventional explosive was ignited and propelled the cylindrical-shaped mass into the center of the rings. The contact of the subcritical masses of U-235 created a critical mass to cause a fission reaction that exploded with the force of approximately 20,000 tons of TNT.

Later gun-type designs created a greater yield by encasing the components with uranium 238 (U-238), a very strong material, to serve as a "tamper" to hold the weapon together longer, allow the fissioning process to continue, and to reflect stray neutrons back into the fission reaction. Both measures led to larger yields.

—Jennifer Hunt Morstein

See also: *Enola Gay;* Fat Man; Fission Weapons; Gun-Type Devices; Hiroshima; Nuclear Weapons Effects

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LONDON NUCLEAR SUPPLIERS CLUB

See Nuclear Suppliers Group

LONG-RANGE THEATER NUCLEAR FORCES

Long-range theater nuclear forces (LRTNFs) are nuclear weapons on delivery systems that can reach deep within an adversary's rear areas, including possibly his home territory. There is no firm distance at which short- or intermediate-range forces are considered long-range TNF, but the upper end of the range spectrum is a bit clearer—LRTNF weapons are shorter range than strategic intercontinental systems.

Debate about long-range theater nuclear weapons rose to prominence in the late 1970s following a decision by the North Atlantic Treaty Organization (NATO) to upgrade its capabilities by deploying Pershing II ballistic missiles and ground-launched cruise missiles (GLCMs) in response to the Soviet military buildup, which included the deployment of the SS-20 intermediate-range ballistic missile (IRBM). Alliance acrimony over the modernization of NATO's LRTNFs added impetus to the rebirth of the peace movement within Western Europe and led to significant protests as individual NATO countries allowed these weapons to be deployed on their territory. Ultimately, all three systems, together with the Soviet SS-4s and SS-5s, were eliminated as part of the Intermediate-Range Nuclear Forces (INF) Treaty of 1987.

Once strategic parity was reached between the Soviet Union and the United States, concern grew within Europe over the nuclear balance within the European theater and the U.S. nuclear guarantee. Because of the close proximity of a number of U.S.

theater nuclear systems to the Soviet Union, the Soviet officials were alarmed about any adverse change in the theater nuclear balance in Europe.

By the mid-1970s, increasing concerns were voiced within NATO about the relative lack of success of détente and the continuing Soviet conventional, tactical nuclear, and long-range theater nuclear weapons buildup within Europe. In May 1977, the NATO heads of state agreed to increase defense expenditures, and in the following year they approved the Long-Term Defence Program (LTDP). This identified nine conventional areas for improvement in addition to the modernization of NATO's long-range theater nuclear forces. In the 1970s, NATO's LRTNFs consisted of five U.S. Poseidon missile submarines with 400 warheads, four British Polaris missile submarines, U.S. F-111 fighter-bombers based in the United Kingdom, and British Vulcan bombers. Some NATO strategists and officials were worried that NATO aircraft were vulnerable to Soviet conventional or nuclear attack and wondered if nuclear-armed missiles launched from the submarines dedicated to NATO missions would be seen as strategic rather than theater nuclear forces by the Soviets. In late spring 1979, NATO's High Level Group put forward a plan to modernize NATO's LRTNFs by deploying a mix of 106 Pershing II missiles and 464 ground-launched cruise missiles (GLCMs) while withdrawing obsolete nuclear weapons deployed as part of NATO's theater nuclear force. The group also agreed on a "dual-track" deployment: NATO LRTNF modernization would be accompanied by negotiations with the Soviet Union to cap, if not eliminate, LRTNFs in Europe.

Soviet leaders immediately attempted to derail NATO's LRTNF plans, arguing that it would upset the delicate military balance in Europe. The Soviets made a series of counterproposals, which NATO found equally unacceptable. Negotiations continued over the years as NATO began deployment of its new weapons and the Soviet Union continued to deploy the SS-20. Wide-scale civilian protests in Western Europe against NATO's LRTNF modernization continued.

Ultimately, LRTNFs were eliminated from the arsenals of the Soviet Union and United States under the INF Treaty. Ironically, as NATO applauded the treaty, the Cold War ended, eliminating the need for LRTNFs in Europe.

—Andrew M. Dorman

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LOS ALAMOS NATIONAL LABORATORY

The U.S. Army established the Los Alamos National Laboratory (LANL) in Los Alamos, New Mexico, in January 1943 to design, assemble, and test the first atomic bombs. During 1942, the War Department had established a site at Oak Ridge, Tennessee, for uranium and plutonium refinement and enrichment, and another site at Richland (Hanford), Washington, for plutonium metal production (*see* Hanford, Washington; Oak Ridge National Laboratory). An expenditure of $1.7 billion and the efforts of thousands of scientists, engineers, and technicians resulted in the development of the first atomic bomb, which was detonated at the Trinity Site near Alamogordo, New Mexico, in July 1945 (*see* Trinity Site). As the sole purpose of the Los Alamos Laboratory was to develop the atomic bomb, the War Department planned to dismantle it upon completion of the project. At the end of World War II, however, distrust of the Soviet Union led to the perception that America needed to further develop its nuclear arsenal, and U.S. officials decided to establish a permanent nuclear weapons research and design operation at Los Alamos. Los Alamos, a 43-square-mile facility, has always operated under a contract with the University of California Board of Regents, and it now employs about 8,000 people.

LANL originally manufactured plutonium pits in small numbers for weapons tests at its TA-55 (Technical Area-55) plant. This 4-acre facility is currently the only full-function plutonium-handling facility in the United States. In 1952, Los Alamos tested the first fusion device at Enewetak Atoll in the Pacific. Until 1958, Los Alamos designed all the nuclear weapons that entered the stockpile. Since then, both Los Alamos and Lawrence Livermore National Laboratory (LLNL) have produced nuclear weapons (*see* Hydrogen Bomb).

Several weapons with Los Alamos–designed warheads are currently in the U.S. nuclear arsenal. The

B-61, designed by LANL for the air force, for example, is equipped with "dial-a-yield," allowing the operator to select the yield of the weapon. There are many versions and modifications of the B-61, the latest being the earth-penetrating B-61-11. Current versions were introduced to the stockpile in 1979.

The W-76 was designed by LANL for the U.S. Navy's Trident I submarine-launched ballistic missile. Each Trident submarine can carry up to 24 missiles with eight warheads each. The W-76 was first deployed in 1979. It was replaced on the Trident II missile by the LANL-designed W-88 beginning in 1986. The W-88 was first deployed in 1990 and is considered the most advanced U.S. nuclear weapon. Its plutonium pit is the first scheduled for refurbishment if and when U.S. stockpile pit production resumes.

The W-78 warhead was designed by LANL as a replacement for the Lawrence Livermore–designed W-62 on the Air Force's Minuteman III ICBMs. It was first deployed in 1979.

The W-80, produced by LANL, is a cruise missile warhead that was first deployed in 1984. W-80s are still in the arsenal for potential use by air- or sea-launched cruise missiles.

The B-53 bomb was a variant of the W-53 Titan II ICBM warhead. Some of these weapons were kept in service following the end of the Cold War, but all have now been retired. The B-53 had the distinction of having the largest yield of any warhead ever produced by the United States, at some 9 megatons. It was originally designed for countervalue targeting against cities, but it probably remains in the arsenal as a tool for digging out underground bunkers or buried facilities for producing weapons of mass destruction.

—Gilles Van Nederveen and Jeffrey A. Larsen

See also: Fission Weapons; Lawrence Livermore National Laboratory; Manhattan Project; Pit; Sandia National Laboratories; Thermonuclear Bomb

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LOW ENRICHED URANIUM (LEU)

Low enriched uranium, or LEU, is uranium that is enriched to less than 20 percent by its fissile isotope, uranium 235 (U-235). Most commercial power reactors require low enriched uranium to function. Typical enrichments for these power plants are between 2 and 5 percent. Some fuels in research reactors, however, are enriched to nearly 20 percent to allow for more compact cores.

Low enriched uranium is mainly produced by processing natural uranium at an enrichment plant. Mixing natural uranium with highly enriched uranium is another way to produce LEU (*see* Enrichment; Highly Enriched Uranium [HEU]; Isotopes; Uranium).

History and Background

Early in the development of nuclear reactors, it was recognized that U-235 is the only naturally available isotope that is fissile. In its natural form, uranium contains only 0.72 percent U-235, severely limiting the availability of this fuel source. To create a critical mass using natural uranium, moderators with special properties were necessary to slow the neutrons down. Owing to the limited amount of fissile uranium available, moderators had to slow these neutrons down without absorbing them, leaving as many neutrons as possible available for fission. This requirement forced scientists and engineers to use graphite and heavy-water moderators in their attempts to build a sustained chain reaction. As the supply of enriched uranium slowly increased, it eventually became feasible to build reactors that used LEU as the fuel source. These reactors could now use light water as the coolant/moderator, which greatly reduced reactor construction and operating costs. Most reactors in the world today use LEU as their fuel source (*see* Light-Water Reactors).

The enrichment processes that are used to create low enriched uranium are similar to the processes used to create highly enriched uranium. Because the different isotopes of uranium are chemically identical, all enrichment schemes rely upon the small mass differences that exist between the isotopes. Gaseous diffusion, gas centrifuge, Becker nozzle, electromagnetic separation, and laser isotope separation are some of the different methods that exploit this mass difference. All of these techniques, except laser separation, require a very large multistage cascade system to achieve significant enrichment. These large cascade systems require large amounts of space and electrical power.

Another method for creating low enriched uranium is through the process of diluting highly enriched uranium with natural uranium. This is often referred to as "downblending." The United States and some former Soviet states use this relatively new method to create low enriched uranium because it allows them to dispose of their inventories of highly enriched (weapons-grade) uranium. Low enriched uranium is unsuitable for use in nuclear weapons.

Technical Details

The primary reason that low enriched uranium is the most prevalent fuel in modern reactors is that fuel enriched in U-235 can use light water as a moderator/coolant. In nuclear reactors, neutrons are more easily absorbed after they have slowed down. Slowing neutrons is called "moderation." To reduce the velocity of neutrons three tasks must be accomplished. First, nuclei should have low mass numbers so that each scattering event causes the neutrons to lose a large fraction of their energy. Second, the nuclei need to have large probabilities that scattering, and hence energy loss, will occur over short distances. Third, moderating nuclei should have low probabilities for absorption so that when scattering interactions take place few neutrons are removed from the system. Light water meets these requirements but sill has a much smaller scattering-to-absorption ratio than either graphite or heavy water. As result, a graphite or heavy-water reactor can use natural uranium as a fuel, but a light-water reactor requires slightly enriched uranium to function (see Gas-Graphite Reactors; Heavy Water).

All current enrichment methods only slightly enrich the uranium as it passes through one of the many stages in the enrichment facility. This process of feeding the material repeatedly through many enrichment stages is referred to as a "cascade system," and the measure of separation that takes place in each stage is called a "stage separation factor." For U-235, the stage separation factor is theoretically limited to 1.0043, but it is typically much closer to 1.003. Using the ideal stage separation factor at a gaseous-diffusion plant, at least 1,100 stages are required to enrich uranium to 3 percent by weight. For a gaseous-centrifuge, the separation factor is higher, and as few as 90 stages may be required for the same enrichment.

—*C. Ross Schmidtlein*

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MANEUVERING REENTRY VEHICLE (MARV)
A maneuvering reentry vehicle (MARV) is a reentry vehicle (RV) capable of performing preplanned flight maneuvers during the reentry phase of its flight trajectory while en route to its target. A MARV deploys fins or other aerodynamic surfaces when it reenters the atmosphere, which allows it to turn and dodge rather than following a standard ballistic course.

MARV technology delivers a wide variety of improvements over a standard RV. The ability to maneuver while dropping to earth allows for higher degrees of accuracy. More accurate and precise modes of delivery of nuclear warheads can help avoid high levels of collateral damage and provides a higher degree of certainty that the warhead will directly hit a target that may be reinforced against indirect nuclear blasts.

Additionally, MARVed warheads can better avoid any antiballistic missile interceptors they encounter in transit to their target. The maneuvering capability could be used to complicate hit-to-kill or conventional warhead ballistic missile defense systems. MARVed warheads may be able to avoid kinetic-kill missile defenses by flying a nonstatic post-boost trajectory that foils attempts to destroy the RV based upon an assumption that it will fly a ballistic reentry course predetermined by its launch trajectory.

—*Abe Denmark*

See also: Reentry Vehicles

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MANHATTAN PROJECT
The United States initiated the top secret Manhattan Project in September 1942 to build an atomic bomb before Germany could develop its own nuclear weapon. The undertaking, named for the fact that it was managed out of the Army Corps of Engineers' Manhattan District, was a massive and costly project engaging many top U.S., Canadian, and British scientists. It benefited from contributions by numerous U.S. corporations and universities. After overcoming substantial scientific, technical, and practical obstacles, the project produced the weapons that were used on Hiroshima and Nagasaki, leading to Japan's surrender in August 1945. (Germany had surrendered in May 1945, before the bombs were ready.) The use of atomic weapons against these two Japanese cities brought a rapid conclusion to hostilities in the Pacific. However, the development and use of atomic weapons, ushering in the nuclear age and a four-decade nuclear standoff between the United States and the Soviet Union, has remained the object of political, policy, and moral debate.

History and Background
The origins of the Manhattan Project were shaped in the crucible of the tumultuous1930s. By 1934, the idea of using nuclear chain reactions to produce an atomic bomb had received a patent in the United Kingdom. Many European scientists who had been working to understand the dynamics and potential of atomic energy sought to escape from the reach of Adolf Hitler's Nazi regime, which targeted the field of physics itself because it was populated by many Jewish scientists. Many of these refugees ended up

Dr. J. Robert Oppenheimer, director of the Manhattan Project and Los Alamos National Laboratory during World War II. (Library of Congress)

making critical contributions to the Manhattan Project.

German scientists had split the first uranium atom in 1938, which provided experimental evidence that it was possible to use nuclear fission to produce a very destructive weapon. The next year, Albert Einstein, who in 1933 had left Germany and settled in the United States, was urged by three Hungarian refugee physicists (Leo Szilard, Edward Teller, and Eugene Wigner) to alert U.S. political authorities to the dangers posed by Germany's nuclear research. Einstein signed a letter to U.S. President Franklin D. Roosevelt describing German atomic research and the possibility that Hitler could produce an atomic bomb based on that research. Roosevelt responded by creating a special Advisory Committee on Uranium, referred to as "S-1." In June 1940, the committee was placed under the auspices of the National Defense Research Committee (NDRC), led by the Carnegie Institution's director, Dr. Vannevar Bush. It immediately launched a major research program through contracts with universities and other institutions. In November 1941, the S-1 committee was placed under the jurisdiction of the U.S. Office of Scientific Research and Development (OSRD), the parent organization of the NDRC.

Much of the research contracted by the Uranium Committee had been oriented toward using uranium 235 (U-235), a rare isotope constituting less than 1 percent of uranium metal in its natural state, to produce a controlled chain reaction. It was not known at that time whether sufficient quantities of highly refined U-235 could be produced to manufacture an atomic bomb. Some experts believed it could not be done, certainly not in the near future. A second broad approach to the problem suggested that U-238, more abundant than U-235, could be converted into plutonium, which then could be used as the foundation for the atomic chain reaction (*see* Enrichment; Highly Enriched Uranium [HEU]; Plutonium; Uranium).

World War II had begun in Europe in September 1939 when Germany invaded Poland and Britain and France declared war on Germany and its allies. The United States remained technically neutral for the next two years even though it provided both material and moral support to Great Britain. Formal U.S. neutrality came to an end when Germany's ally Japan mounted a surprise attack on U.S. naval facilities in Pearl Harbor, Hawaii, on December 7, 1941, bringing the United States into the war against the Axis Powers.

The Project

On June 17, 1942, Vannevar Bush reported to President Roosevelt that the Uranium Committee's research program had demonstrated that production of fissionable uranium and plutonium could produce an atomic weapon. Roosevelt decided to move the atomic program from the research and development stage to large-scale production. That same month, Roosevelt directed the army to manage this transition, and the task was given over to the Army Corps of Engineers, which created a new organization known as the "Manhattan Engineer District (MED)," located in New York City. The Manhattan Project got under way in September. West Point graduate and army engineer Leslie R. Groves was chosen as its director and promoted from colonel to brigadier general so that he would have the status and authority required for the important job.

General Groves was known for his ability to deliver results irrespective of whose toes he had to step on or whose feelings he might hurt. He took on the task somewhat reluctantly, having preferred an assignment in an active theater of operations to another Washington posting. He later wrote that his initial reaction was one of "extreme disappointment." However, the disappointment was mitigated when he was told that his appointment had been made by the secretary of war and approved by the president. One official told him, "If you do the job right, it will win the war" (Groves, pp. 3–4).

Groves's initial assignment was to organize production of the atomic bomb. It soon became clear that the production effort could not succeed unless ongoing research efforts were focused more effectively on the practical task of producing enough fissionable material to yield several bombs. The Uranium Committee's research programs had focused on five basic ways of producing fissionable material: U-235 could be separated from the parent uranium by using a centrifuge, gaseous-diffusion, or electromagnetic process; or plutonium could be produced by organizing uranium and graphite blocks in a "pile," or reactor, or in a reactor using heavy water instead of graphite to control the chain reaction during the production process. The Uranium Committee decided to move all five approaches from the research to the production stage. General Groves, after examining research into the centrifuge separation method at the University of Virginia and the Westinghouse Research Laboratories in Pittsburgh, Pennsylvania, decided to drop further work on this method and concentrate on the other four.

Atomic research was being conducted in a number of locations across the country, but three became critical centers for the transition from research to production. Scientists at Columbia University in New York, under the direction of Professor Harold Urey, concentrated on issues related to using gaseous diffusion to separate out U-235. Scientists at the University of California at Berkeley, led by Professor Ernest O. Lawrence, worked on the process of electromagnetic separation. And at the University of Chicago, a team of scientists led by Arthur Compton and including Italian Nobel Prize winner Enrico Fermi as well as Hungarian expatriate physicists Leo Szilard and Eugene Wigner concentrated on the process of producing fissionable plutonium with the uranium/graphite pile. A critical breakthrough in the research process came in December 1942 when Fermi demonstrated the first self-sustaining nuclear chain reaction at a pile built under a squash court at the University of Chicago.

The scientific challenges posed by the project were considerable, including the seemingly mundane but extremely difficult tasks of developing filters, valves, pipes, and other processing equipment to stand up to demanding production requirements. Equally challenging was the task of building facilities for production processes that were still being developed. In November 1942, a remote and undeveloped site in Los Alamos, New Mexico, was selected as the location for a laboratory in which the actual production of atomic bombs would take place (*see* Los Alamos National Laboratory). Dr. Robert J. Oppenheimer, from the University of California–Berkeley, was chosen to head the lab. Also late in 1942, a large site in Oak Ridge, Tennessee, was selected for construction of what was then called the "Clinton Engineer Works," renamed after the war as the Oak Ridge National Laboratory (*see* Oak Ridge National Laboratory). The site became the factory for the production of plutonium in "the Clinton Pile," and for separation of U-235 in gaseous-diffusion and electromagnetic plants. The main production facilities for weapons material were the K-25 gaseous-diffusion plant, the Y-12 electromagnetic plant, and the S-50 thermal-diffusion plant.

A third major facility, the Hanford site, was constructed in Richland, Washington, to produce plutonium. At the peak of the construction effort, some 45,000 construction workers were employed at the Hanford site, with 11,000 pieces of major construction equipment on hand (*see* Hanford, Washington).

All three facilities had to be built quickly and without knowing exactly how all the production methods would work. The projects included housing for the construction workers, engineers, and scientists who would construct and operate the facilities. The purpose of the facilities was closely held, and most of the thousands of engineers, construction workers, and technicians had no idea exactly what the facilities were intended to produce. The project relied on contributions from many of America's major companies, including Allis-Chalmers, Celotex, Chrysler, Dupont, Eastman Kodak, Goodyear, IBM, Ingersoll-Rand, International Nickel, Stone and Webster, Union Carbide, and Westinghouse,

As the Manhattan Project approached the point where enough fissionable material would be available to produce a few weapons, the war in Europe moved toward a successful conclusion. The end of the Third Reich and Germany's surrender in May 1945 removed the threat of a German-produced atomic bomb being used against the United States or its allies. In fact, Germany's nuclear weapons program had been severely disrupted by Norwegian resistance fighters, who had bombed the German heavy-water facility in occupied Norway; when it was repaired, it was bombed again by Allied forces.

Japan remained a stubborn combatant, and President Harry S. Truman, who had succeeded Roosevelt after his death early in 1945, decided to use nuclear weapons against Japanese cities to force a Japanese surrender (the deaths of over 100,000 Japanese civilians in firebombing attacks against Tokyo had not accomplished that goal).

The development of U-235 weapons and those made from plutonium, in spite of various setbacks along the way, came to fruition at roughly the same time in 1945. The first U-235 bomb produced was detonated on July 16, 1945, at a test range in Alamogordo, New Mexico, with Robert Oppenheimer in charge. The test site was code-named "Trinity" (*see* Trinity Site). With the test's success, two other weapons, nicknamed "Little Boy" and "Fat Man," were rushed to an air base in the Pacific. On August 6, 1945, Little Boy, a U-235 weapon, was flown from a U.S. air base on Tinian in the Marianas Islands on a B-29 named *Enola Gay* and dropped on the city of Hiroshima, Japan. Fat Man, a plutonium bomb, was dropped by another B-29, *Bockscar,* on Nagasaki, Japan, on August 9. Japan surrendered three weeks later, bringing World War II to an end.

Consequences

The Manhattan Project produced atomic weapons that were used to expedite the end of the war against Japan. The overall cost of the effort has been estimated at $20 billion (in 1996 dollars), for a cost of approximately $5 billion per bomb (the one that was tested at Alamogordo, one each delivered on Hiroshima and Nagasaki, Japan, and one that remained unused). In spite of the extraordinary security that surrounded the Manhattan Project, the Soviet Union managed to obtain critical nuclear secrets from spies inside the project. The acquisition of this information greatly facilitated the development of the Soviet nuclear weapons program, leading to the Cold War nuclear standoff that ended only when the Soviet Union and the Warsaw Pact began disintegrating in 1989. The reality of widespread nuclear proliferation today ensures that nuclear weapons technology, first brought to use in war through the Manhattan Project, will remain a source of debate and division in global affairs.

—Stanley R. Sloan

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MASSIVE RETALIATION

Massive retaliation is a theory of deterrence that holds that conventional wars and nuclear attacks can be deterred by the threat of responding with massive nuclear retaliation endangering the very survival of the targeted state or society. As a national security doctrine or policy, it was used by the Dwight D. Eisenhower administration to justify the expansion of U.S. nuclear forces in the 1950s and to limit the need for standing conventional forces, which were considered more expensive to acquire and maintain. Furthermore, it was assumed that nuclear forces could substitute, in a deterrence strategy, for extensive conventional forces. Under this doctrine, U.S. nuclear forces expanded from approximately 250 nuclear devices in 1949 to more than 18,000 tactical, theater, and strategic nuclear weapons by 1960.

The declared public doctrine of massive retaliation also was used to cope with the threat of limited, peripheral wars threatened by the Communist Soviet bloc as well as the threat of a Soviet invasion of Western Europe. By threatening a massive nuclear retaliation, the United States hoped to offset perceived Soviet superiority in conventional military forces in Central Europe. Shortly after World War II, it became clear that a doctrine of "anywhere, anytime" defense would become an enormous fiscal burden, and the Eisenhower administration soon adopted the "New Look" doctrine, which placed emphasis on responding to aggression by threatening a massive retaliation "at places and times of our own choosing," in the words of John Foster Dulles, secretary of state under President Eisenhower (Dulles, p. 143).

There was a mismatch between the "declaratory" and "operational" policies of massive retaliation. Publicly, U.S. officials declared that the United States would respond to limited Soviet or Chinese aggression with massive nuclear strikes against the aggressor's homeland. The U.S. military, however, planned to respond in a flexible manner at times and places of its own choosing, selecting options from the full spectrum of U.S. military capability, from conventional forces up to limited nuclear strikes or massive nuclear retaliation. Despite the popular image of nuclear weapons as "city busters" and of nuclear strategy as a "countervalue targeting" option, the actual targeting policies were decidedly "counterforce," that is, directed at military targets (*see* Conterterforce Targeting; Countervalue Targeting). Nevertheless, in execution, this targeting strategy included both military bases and the Soviet military-industrial complex, including facilities in or near 118 of the 134 largest cities in the Soviet bloc, and would have resulted in millions of casualties. In this sense, it would have been indistinguishable from a true "countervalue" strike deliberately aimed at cities.

Massive retaliation was a declaratory policy well-suited to an era of American nuclear monopoly and superiority. Nevertheless, the doctrine of massive retaliation was short-lived. Its credibility was eventually undermined by the Soviet acquisition—in the late 1950s and early 1960s—of an ability to use nuclear weapons to hold U.S. cities at risk, thus matching America's threat of massive retaliation. Once the United States itself was subject to such an attack, it became less credible to threaten massive retaliation (*see* Credibility). The John F. Kennedy administration moved to adopt a new doctrine of "flexible response" that was reflected in the emergence of a new "balance of terror" in Soviet-American relations.

—*Kerry Kartchner*

See also: Balance of Terror; Cold War; Flexible Response; New Look; Second Strike

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MEDIUM-RANGE BALLISTIC MISSILES

Medium-range ballistic missiles (MRBMs) are offensive strike systems capable of carrying conventional or nuclear warheads over a range of hundreds of miles. Like a few other delivery systems, especially cruise missiles, MRBMs have come and gone repeatedly since their initial appearance in the late 1950s. Originally developed by the Soviet Union and the United States to attack each other, they were long viewed as the most destabilizing nuclear weapons delivery systems. Today they are deployed exclusively by other powers to reach targets in their own vicinity.

Definitions of MRBMs vary depending on the motives involved. Most countries never developed a formal definition because they had no such weapons or no ballistic missiles larger than MRBMs. The U.S. Department of Defense distinguished short-range weapons placed under the control of corps or regional theater commanders and intercontinental ballistic missiles (ICBMs) under Strategic Air Command (now Strategic Command). Under this approach, an MRBM is a ballistic missile with a range of between 1,100 and 2,750 kilometers (600 to 1,500 nautical miles). In practice, this is often rounded to 1,000 to 3,000 km.

The problem of defining MRBMs was complicated by a shift in language in the mid-1970s that came with the appearance of the new generation of missiles led by the Soviet SS-20. The term "intermediate nuclear forces" (INF) took the place of "medium-range ballistic missiles" in strategic discussions, although the two terms often referred to exactly the same weapons.

First-Generation MRBMs

First-generation MRBMs were not developed because of intrinsic interest in their specific capabilities. They emerged, rather, as a way of coping with the limits of early rocket technology. By 1954, both superpowers were committed to developing long-range ICBMs, but this technology was complex and slow to be perfected. Medium-range systems offered a seemingly elegant shortcut, a way to use some of the simpler components of ICBMs in more rapidly developed weapons. Although these could not fly all the way from one superpower to another, they could be based in other countries or targeted at an enemy's allies.

The first generation of MRBMs, weapons such as the U.S. 2,400-kilometer-range Jupiter and Thor and the Soviet SS-3, SS-4, and SS–5, used engine designs originally developed for the still emerging ICBMs. Instead of multiple staging, storable fuels, inertial guidance, and high-beta reentry vehicles, none of which had been perfected by the late 1950s, these systems were designed to use proven, albeit less desirable, technologies. As a result, they were single-stage designs burning cryogenically cooled liquid oxygen, mostly using strap-down inertial and radio-command guidance and heat-sink reentry vehicles. Like all MRBMs deployed by the superpowers, they were armed exclusively with nuclear warheads.

Because of their limited range, they had to be based close to their targets. Since they could not be fueled until just before launch, a process taking an hour or more, they required a lengthy countdown. They were not highly accurate and thus could only target cities. All of this made them tempting targets vulnerable to preemptive attack. Not surprisingly, they usually were decommissioned or upgraded as quickly as possible.

The United Kingdom canceled its Blue Streak MRBM program in 1960. The United States, which had deployed Thor missiles in the United Kingdom and Jupiters in Italy and Turkey, eliminated all its first-generation MRBMs after the 1962 Cuban missile crisis. The Soviet Union got rid of its SS-3 inventory but retained its SS-4s and SS-5s, slowly upgrading their capabilities as better technologies appeared. China deployed its first aboveground DF-2, a 1,200 km MRBM using cryogenic liquid oxygen, in 1966. This was replaced by the DF-3, a 2,800 km MRBM, deployed initially in 1971. China also sold DF-3 missiles to Saudi Arabia in the late 1980s. France deployed a silo-launched MRBM of its own, the S2, with a range of 3,500 km, in 1971. Both the DF-3 and the S2 used storable liquid propellant.

Second-Generation MRBMs

A second generation of MRBMs appeared in the mid-1960s. Weapons such as the American Pershing I and the Soviet SS-12 had less range, but in exchange for this decrease in performance and the switch to storable propellants, they could be readily transported. This mobility greatly reduced their vulnerability to preemptive attack. An even more important role for missiles in this category was as submarine-launched ballistic missiles, such as the American Polaris A1 (operational in 1962), the French M1 (1972), and the Chinese JL-2 (1982). All of the latter were MRBMs in term of range, but they had multiple stages and used fully inertial guidance.

Third-Generation MRBMs and INF

Largely forgotten in strategic discussions, land-based MRBMs drifted to the background of superpower force postures until their importance revived in the mid-1970s following initial deployment of the Soviet SS-20. This road-mobile system, using solid fuels and multiple warheads, was not vulnerable to preemptive attack. By giving the Soviet Union the ability to attack Western Europe separately from the United States, it represented a major challenge to the strategy of flexible response adopted by the North Atlantic Treaty Organization (NATO). The United States developed the Pershing II in response to the SS-20. Both weapons, along with all other Soviet (Russian) and U.S. MRBMs, were banned under the 1987 Intermediate Nuclear Forces (INF) Treaty.

Current Status

Just as MRBMs were being eliminated from superpower forces, they found a new role as the weapon of choice for many regional ballistic missile forces. This had been presaged by weapons such as the Israeli Jericho, reportedly a 500 km system based on French technology, first deployed in the early 1970s. In 1988, Iraq attacked Iran with several hundred Scud missiles modified to reach distances of 600 km, the same missiles it fired at Israel and allied targets in 1991. In 1989, India began testing developmental models of its Agni, a solid-fuel intermediate-range ballistic missile (IRBM) with a range of approximately 1,500 km (see Indian Nuclear Weapons Program; Iraqi Nuclear Forces and Doctrine; Israeli Nuclear Weapons Capabilities and Doctrine.)

The greatest source of MRBM technology and complete systems is North Korea, which developed the Nodong, a single-stage weapon with a range of 1,300 km that appears to be based on Scud technologies. Since its first flight in 1993, versions of the Nodong have appeared in Pakistan and Iran. Pakistan also has developed a family of solid-fuel MRBMs, known as the Shaheen-1 and -2, and the Haft-5 and -6. These appear to be single-stage missiles with a range of 800 km and two-stage missiles with a range of 2,500 km, respectively, versions of the same basic motor. The Pakistani solid-fuel MRBMs bear a clear similarity to Chinese missiles such as the M-9, on which they are widely thought to be based.

—*Aaron Karp*

See also: Iranian Nuclear Weapons Program; North Korean Nuclear Weapons Program; Pakistani Nuclear Weapons Program

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MEGATON

A megaton is a measure of the energy released during a nuclear explosion. One megaton is equal to 1 million tons of trinitrotoluene (TNT), a high explosive. This definition refers to all of the energy released by the weapons, regardless of the form. When a nuclear explosion occurs, only a small part of the released energy is in the form of explosive energy, whereas the energy of a chemical explosion is mostly released as blast. The Hiroshima explosion was estimated to be 12–18 kilotons (or 0.18 megaton). The largest U.S. detonation was the Castle/Bravo test in 1954, which had a yield of 15 megatons. The Soviet Union reportedly tested a hydrogen bomb in 1961 that measured 58 megatons.

—*Zach Becker*

See also: Equivalent Megaton; Hydrogen Bomb; Kiloton; Thermonuclear Bomb

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MEGAWATT

A megawatt is a unit of power equal to 1 million watts. Commercial nuclear power plants normally produce thousands of megawatts of power.

The first nuclear reactor, built at Hanford, Washington, in 1943, generated 250 megawatts of thermal power, that is, 100 million times more power than the 2 watts produced by Enrico Fermi's experimental pile at the University of Chicago in 1942 (*see* Hanford, Washington; Manhattan Project).

A megawatt (electric), abbreviated MWe, is equal to 1 megawatt of electric power, and a megawatt (thermal), abbreviated MWt, is equal to 1 megawatt of thermal power. Nuclear reactors are approximately 30 percent efficient at converting thermal power generated by the fission process to electric power. In terms of converting megatons to megawatts, a megaton of explosive energy is approximately equivalent to the heat generated by a 1,000 MW nuclear power plant operating for about 20 days.

Approximately 440 nuclear power plants worldwide produce about 350,000 MWe. There are 103 nuclear power plants in the United States producing about 86,000 MWe of power.

In the 1990s, the United States began to purchase highly enriched uranium (about 90 percent enriched with uranium 235) from the Russian nuclear weapons industry to convert it to reactor-grade uranium (3 to 5 percent enriched). The United States Enrichment Corporation manages this program to convert potential megatons of explosive energy into megawatts of power.

—*Don Gillich*

See also: Ballistic Missiles; Highly Enriched Uranium; Intermediate-Range Nuclear Forces; Low Enriched Uranium

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MIDGETMAN ICBMS

The Midgetman program was a plan to deploy a new series of single-warhead intercontinental ballistic missiles (ICBMs) on mobile launchers. It was the direct result of the 1983 Scowcroft Commission Report, the findings of a Commission on Strategic Forces led by Lieutenant General Brent Scowcroft, USAF (ret.), on the increasing vulnerability of U.S. ICBMs to destruction by a Soviet nuclear strike.

ICBM vulnerability had been the subject of considerable debate within the United States as the Soviet Union began to equip heavy ICBMs with multiple independently targetable reentry vehicles (MIRVs). In the early 1980s, the U.S. Air Force had hoped to deploy the large MX ICBM with its highly accurate MIRV warheads to increase the prompt hard-target kill capability of the U.S. "Triad" of nuclear forces (ICBMs, submarine-launched ballistic missiles [SLBMs], and manned bombers). The U.S. Congress, however, had expressed its reservations about the various basing models proposed for the MX because they did little to protect the new missile from a Soviet first strike. President Reagan appointed the Scowcroft Commission to recommend ways to improve the survivability of the land-based leg of the U.S. strategic deterrent. The commission recommended limiting the size of the MX missile deployment and proposed the deployment of 600 mobile, single-warhead ICBMs, dubbed Midgetman. The Midgetman transporter would have been capable of off-road movement, reducing its vulnerability to a Soviet nuclear attack.

The Reagan administration was never supportive of the Midgetman program. Instead, it believed that the Strategic Defense Initiative (SDI) offered the best long-term solution to the problem of ICBM survivability. The Midgetman ICBM program was terminated following the end of the Cold War

—Andrew M. Dorman

See also: Intercontinental Ballistic Missile; Strategic Defense Initiative

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MILITARY TECHNICAL REVOLUTION (REVOLUTION IN MILITARY AFFAIRS)

A "military technical revolution" (MTR) occurs gradually when new systems and technology are applied to existing concepts of warfare. The development and use of aircraft carriers, which extended the striking range of naval forces and replaced battleships as the dominant warship on the high seas, for example, constituted an MTR. A "revolution in military affairs" (RMA) encompasses profound changes in military technology that affect the conduct of warfare. In an RMA, the innovative application of new technologies causes dramatic changes in military doctrine and operational and organizational concepts, fundamentally altering the character and conduct of military operations. An RMA thus involves a paradigm shift in the nature and conduct of military operations that renders one or more core competencies of a dominant player obsolete or irrelevant. Alternatively, this shift creates one or more new core competencies in some new dimension of warfare.

An MTR is an evolutionary, not a revolutionary, process: It develops as new technology is incorporated into existing doctrine and organizations. Today, an MTR is under way as advances in computers, telecommunications, and robotics—to name a few obvious technological candidates—are being integrated into military forces.

By contrast, an RMA has a revolutionary effect on warfare. It occurs when technological advances stimulate radical changes in military affairs. The nuclear revolution, for example, had the effect of changing the fundamental nature of warfare. Before nuclear weapons, military forces were intended to achieve victory in war. After the advent of nuclear weapons, the primary purpose of military forces was to deter war.

—Bret Kinman

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MINIMUM DETERRENCE

Minimum deterrence is predicated on the ability of a state to absorb a nuclear strike and maintain the ability to inflict enough of a damaging nuclear strike on the enemy's population centers to deter the initial nuclear strike. It encompasses the idea that only a limited retaliatory capability of a few score nuclear weapons is sufficient for a credible nuclear threat, regardless of the size of the opponent's arsenal. Although at first the size and then the capability of both Soviet and U.S. nuclear arsenals increased during the Cold War, advocates of minimum deterrence believed that the arms race had produced a situation of unnecessary "nuclear overkill" and that a small, secure second-strike capability was sufficient to deter nuclear attack. Critics of the concept stated that small nuclear forces lacked redundancy and in the end would offer a tempting target to an opponent wishing to obtain a first-strike capability.

In the aftermath of the Cold War, states with small nuclear arsenals—France, the People's Republic of China, India, and Pakistan—seem to have adopted minimal deterrent postures out of necessity, if not strategic choice. At the heart of this doctrine is the idea that the major nuclear powers will not be willing to lose a population center during a conflict with a foreign nuclear power and therefore will be deterred by the threat of even minimal retaliation.

—Abe Denmark and James J. Wirtz

See also: Deterrence; Extended Deterrence

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MINISTRY OF ATOMIC ENERGY (MINATOM)

In January 1992, following the dissolution of the Soviet Union, the Russian Federation Ministry of Atomic Energy (MINATOM) was established by presidential decree. MINATOM, which replaced the Soviet Ministry of Atomic Power and Industry, controls 151 production and research facilities. At the time it was established, it employed approximately 1 million people. The ministry has its own education and training institutes, export organization, and banks.

MINATOM is responsible for the production of all Russian nuclear materials and the development, testing, and production of its nuclear weapons. It is also responsible for the elimination of nuclear warheads and nuclear munitions as stipulated by various treaties. Responsibility for decommissioned nuclear-powered submarines was transferred from the Ministry of Defense to MINATOM in late 1998. The ministry controls most of the weapons-usable highly enriched uranium and plutonium not contained in nuclear weapons. It also has responsibility for Russia's commercial nuclear power program, nuclear safety oversight, basic and applied research, and the conversion of military facilities to civilian uses.

MINATOM was restructured at the end of 1998. It consists of fourteen departments: Nuclear Fuel Cycle; Nuclear Munitions Development and Testing; Nuclear Munitions Production; Nuclear Power Engineering; Industry Economics and Planning; Social Policy, Industrial Relations, and Cadres; Security and Emergency Situations; International and Foreign Economic Cooperation; Nuclear Science and Engineering; Finances, Analysis, and Calculations; Protection of Information, Nuclear Materials, and Facilities; Construction of Nuclear Facilities; Regulatory-Legal Support and Regulation of Forms of Ownership; and Nuclear Industry Conversion.

—Steven Rosenkrantz

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MINUTEMAN ICBM

The U.S. LGM-30 Minuteman is a three-stage, solid-fuel intercontinental ballistic missile (ICBM) with a range of approximately 5,500 nautical miles. It possesses an inertial guidance system and is deployed in hardened underground launch silos.

History and Background

Minuteman grew out a series of design studies initiated in the mid-1950s to develop a simple, efficient three-stage solid-fuel ICBM that could be produced and deployed in large numbers. Development of the missile began in the summer of 1957. A consortium of five contractors produced four distinct Minuteman models: Minuteman I (models "A" and "B"), Minuteman II (model "F"), and Minuteman III (model "G").

During the early development of the missile, the Strategic Air Command (SAC) favored deploying at least a portion of the force on railroad cars. The air force, by contrast, emphasized a silo-based missile. In March 1961, President John F. Kennedy deferred the development of a mobile missile in favor of the silo-based model, and in December of that year Secretary of Defense Robert McNamara canceled the mobile Minuteman program.

Minuteman IA achieved initial operational capability (IOC) in December 1962 with twenty missiles. A full squadron was on alert by the end of February 1963. The Minuteman I was based in hardened, widely dispersed underground silos. An underground launch control center monitored each flight of ten launch facilities, with five flights per squadron. The first Minuteman IB entered service on September 30, 1963.

In 1966, the U.S. Air Force initiated the Minuteman Force Modernization Program to replace all Minuteman Is with either the Minuteman II or III. The program continued through the late 1960s and into the mid-1970s. The Minuteman I was deactivated in 1972 when the air force began fielding the Minuteman III.

Minuteman II had an improved second stage and a dramatically improved guidance system and was equipped with microelectronic circuitry. It achieved IOC on October 31, 1965. In all, 1,000 Minuteman IIs were deployed.

The Minuteman III was the world's first ICBM to carry multiple independently targetable reentry vehicles (MIRVs). It featured an enlarged third stage as well as a new warhead section, or "bus," that housed the guidance system, its own liquid-fueled rocket motor, and three warheads with reentry vehicles. The missile went into regular development in 1966 and was first deployed in April 1970. A total of 500 Minuteman IIIs were fielded. Each missile was deployed with three warheads; there were 200 missiles with W-62 warheads and Mk-12 reentry vehicles, and 300 missiles with larger-yield W-78 warheads and Mk-12A reentry vehicles.

Current Status

All 500 Minuteman IIIs—located at F. E. Warren Air Force Base, Wyoming; Malmstrom Air Force Base, Montana; and Minot Air Force Base, North Dakota—are expected to stay in the U.S. inventory until 2020. When the Peacekeeper ICBM is retired, the Minuteman III will become the only U.S. ICBM. Under the Safety Enhanced Reentry Vehicle program, some Minuteman IIIs will be downloaded to a single W-87 warhead and Mk-21 reentry vehicle. The missile also is to be fitted with the Peacekeeper's Advanced Inertial Reference Sphere. To increase its service life, its aging solid-fuel first and second stages will be refilled with new propellant and bonding materials and its third stage will be remanufactured.

—Tom Mahnken

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MISSILE DEFENSE

The term "missile defense" refers to a system or systems designed to defend against ballistic missile attack, including both active and passive measures to detect, identify, assess, track, and defeat offensive ballistic missiles during any portion of their flight trajectory. It most often refers to the use of ballistic missiles to shoot down other ballistic missiles but may include other means of interception such as directed-energy or laser weapons. The term "antiballistic missile" refers strictly to a ballistic missile that intercepts another ballistic missile. The term "ballistic missile defense" is sometimes used interchangeably with the term "missile defense" and can refer either to defense against ballistic missiles (such as silo-based intercontinental ballistic missiles, or ICBMs) by any means, or defense of any potential target by means of antiballistic missiles (*see* Ballistic Missiles).

History and Background

Throughout most of the Cold War, missile defenses were divided into two categories. "Theater missile defense" referred to defense against short-, medium-, or intermediate-range ballistic missiles and was associated with defense of forces deployed to a given theater of combat against ballistic missile attack. "National missile defense" referred to broader defense of the national territory against long-range or intercontinental ballistic missiles. This distinction was institutionalized by the 1972 Anti-Ballistic Missile (ABM) Treaty, which strictly limited the development and deployment of missile defenses against intercontinental missiles but did not limit theater missile defenses (*see* Anti-Ballistic Missile Treaty). Following U.S. withdrawal from the ABM Treaty in June 2002, and the blurring of technological distinctions between systems designed to detect and counter intercontinental ballistic missiles and those designed to detect and counter shorter-range ballistic missiles, however, the distinction between theater missile defense and national missile defense has nearly faded away. Those systems devoted to missile defense are now grouped into three categories, depending on that phase in the trajectory of an incoming missile during which interception is intended to occur. These are the boost phase, the mid-course phase, and the terminal phase. Attempting to intercept a missile during each phase poses its own advantages and challenges from the defender's perspective.

During its "boost phase," an offensive missile's booster rockets continue to fire, lifting it into a ballistic trajectory. This phase is very short, lasting anywhere from 3 to 10 minutes. The missile may attain an altitude of up to 200 kilometers, and the heat generated by the firing rocket plumes during this phase presents a brighter, more easily detected thermal signature, facilitating detection, tracking, and identification, especially from space-based infrared sensors. Since the missile is traveling relatively slowly in the early stages of this phase, it may be more easily intercepted by high-acceleration ground- or sea-based interceptors located within range, or by air- or space-based directed-energy or kinetic-kill mechanisms. Decoys or other devices intended to distract or confuse the interceptor missile will not have been released during this phase, thus easing the problem of discriminating between the warhead and other items traveling through space

An exoatmospheric kill vehicle interceptor is launched from the Kwajalein Atoll in the Marshall Islands during a test in March 2002. (Reuters/Missile Defense Agency/Corbis) with it. In many hypothetical scenarios, space-based missile defense systems would be ideally suited to attempting boost-phase intercepts, since they would be based in orbit high above the launching territory, although the practical development and deployment of such systems are many years off. Missiles launched from deep inside an attacking nation's territory, however, may be difficult to reach by land- or sea-based interceptors. Since this phase is very short, warning and response timelines must be extremely compressed, making it challenging to detect and assess a hostile launch and then cue and direct interceptors in time to destroy the attacking missile while it is still in the boost phase of its flight. Also, it is difficult to determine a missile's ultimate trajectory or intended impact point during the first moments of its flight while it is striving to escape gravity, so unless the missile's basing or other characteristics allow a predetermination of its hostile intent, or the launch occurs in the midst of a crisis or conflict, it may not be possible to ascertain in a timely manner whether it is a peaceful space launch or an attack (*see* Boost-Phase Intercept).

During the "mid-course phase," the missile's boosters cease firing and the warheads, and in many cases decoys, separate from the third stage. This phase may last up to 20 minutes, constituting the longest portion of the trajectory, and thus offers the best opportunity for an adversary to track the missile, assess its intended target, and attempt one or more intercepts. Most concepts for a national missile defense are designed to achieve interception during this phase. The land-based, long-range missile defense system that the United States is currently beginning to deploy in Alaska and California is a mid-course interception system. Nevertheless, interception during this phase poses its own set of challenges. Offensive missiles may release multiple warheads and/or penetration aids, such as decoys or chaff, during this phase or incorporate other ways of complicating the task of discriminating between warheads and other items and avoiding interception (*see* Decoys; Penetration Aids).

The "terminal phase" begins upon a missile warhead's final approach to its intended target. For intercontinental ballistic missiles and long-range theater missiles, this phase begins with the warhead reentering the atmosphere and may last for only a minute or less. At this point, the warhead is traveling at its fastest speed, leaving only a slight window for attempting an intercept. The atmosphere, however, tends to strip away decoys and chaff upon reentry, simplifying the discrimination task. Terminal defense systems can only provide protection to individual targets or to discrete assets such as troop concentrations, ports, airfields, staging areas, or command and control posts (*see* Terminal Phase).

Kill Mechanisms

A variety of kill mechanisms have been devised to achieve the destruction of an incoming missile or warhead, though not all have been fully developed or even tested. Blast fragmentation devices are designed to explode in proximity to an incoming warhead or missile and to destroy or damage it through collisions with fragments of the interceptor warhead. This is the mechanism employed by most theater missile defenses, and its shortcomings were highlighted by the partial successes of the Patriot missile defense efforts to shoot down Iraqi Scud missiles during the 1991 Persian Gulf War. Early U.S. and Soviet antiballistic missile systems employed nuclear warheads as their primary kill mechanism. The Russian ABM system around Moscow still carries interceptor warheads that rely on nuclear blasts to destroy incoming warheads. Sometime in the late 1980s, the United States made a decision to forgo using nuclear weapons as a missile defense kill mechanism for political and technical reasons, including the fratricide problem (that is, the chance that the nuclear blast would do as much or more damage to U.S. space assets as it did to incoming enemy warheads), a political commitment to cease further nuclear tests, which would have been necessary to develop a missile defense warhead, and an emerging confidence in kinetic kill mechanisms. Kinetic kill mechanisms, or hit-to-kill devices, use the tremendous energy released by direct collisions between interceptors and attacking warheads, both traveling thousands of miles per hour. Such collisions obliterate both the interceptor and the offensive warhead so thoroughly that any nuclear, biological, or chemical weapon carried by the offensive warhead is incinerated. The long-range missile defense system the United States is deploying beginning in 2004 will use a kinetic kill vehicle. Another kill mechanism that is under study employs focused or directed high-energy beams, such as laser or X-ray beams, to destroy missiles. The Israeli government has developed a ground-based antimissile laser device that has been effective in tests against short-range battlefield rockets, and the United States is developing an airborne antimissile laser based on a Boeing 747 aircraft frame that is expected to be tested in 2004–2005.

Political Considerations

Few issues in the field of foreign and defense policy have been of such enduring controversy and debate as missile defense. This debate, which has raged since the mid-1960s, has revolved around two basic questions: (1) *Could* a truly effective and affordable missile defense system be developed and deployed? And, (2) *Should* such a system be developed and deployed, even it if is possible to build one? The first question involves issues of technology, the reliability of complex command and control networks, the pros and cons of automated decision-making, resilience in the face of countermeasures, and the rigors and "realism" of the testing regime. The second question concerns the implications of deploying a missile defense system for international and regional stability in general, for its potential to provoke action-reaction arms races, for whether it would help or hinder efforts to combat the proliferation of weapons of mass destruction and offensive ballistic missile threats, and for whether it would undermine or buttress chances for achieving further strategic arms reduction agreements. These same issues were revisited during the course of three successive debates on missile defense. The first occurred during the mid- to late-1960s and into the early 1970s, culminating in the conclusion of the ABM Treaty in 1972, which settled the debate in favor of those opposed to missile defense. The debate was revived again in the early 1980s when President Ronald Reagan called for the development of a Strategic Defense Initiative (SDI) to provide a hemispheric shield against a potential attack by thousands of Soviet ballistic missiles. This debate was rendered moot by the dissolution of the Soviet Union, after which subsequent administrations dramatically reduced and dismantled the SDI program (*see* Strategic Defense Initiative).

The administration of Bill Clinton (1992–2000) responded to the fall of the Soviet Union by reconfirming the status of the ABM Treaty as the "cornerstone of strategic stability" and discontinuing negotiations with Russia for a cooperative evolution toward a "Global Protection Against Limited Strikes," or GPALS, system. The GPALS system was aimed at loosening or amending ABM Treaty restrictions on missile defense and would have led to the joint development of a modest capability to intercept missile launches by rogue states in certain regions (*see* Global Protection Against Limited Strikes). During the first Clinton administration, funding for SDI was reduced by nearly 80 percent, for theater missile defenses by nearly 25 percent, and for advanced science and technology research by over 95 percent. Nevertheless, the debate over missile defense flared up again for the third time in the late 1990s in the face of increasing proliferation of ballistic missiles among rogue states, and in particular by North Korea's test launch of a three-stage missile of apparent intercontinental range in August 1998. The Clinton administration formulated four criteria for evaluating whether to deploy some form of missile defense as a response to the proliferation threat: the degree to which the threat of ballistic missile attack justified such a response; whether a technically feasible system could be developed; the affordability of such a system; and the likely impact of a U.S. decision to deploy missile defenses on the ABM Treaty and other U.S. arms control and nonproliferation objectives. Eventually, in a speech given on September 1, 2000, President Clinton chose to defer a decision on deploying a missile defense system, largely out of concern about its anticipated impact on U.S.-Russian relations and arms control.

Shortly after assuming office in January 2001, President George W. Bush declared that it was the policy of his administration to deploy a limited missile defense capability as soon as technically feasible. The Bush administration believed that the ABM Treaty had blocked fully exploring all technological avenues of achieving an effective missile defense, that an effective system was affordable, that it was justified by the prospective threat, and that the arms control and international stability ramifications could be managed. In December 2001, President Bush exercised the U.S. right to withdraw from the ABM Treaty on six months' notice, and shortly afterward he announced a decision to begin deploying a limited missile defense system in 2004. This system was to consist initially of twenty silo-based midcourse interceptors deployed in Alaska and California, up to twenty sea-based interceptors on existing Aegis ships, deployment of air-transportable Patriot

Advanced Capability-3 (PAC-3) missiles, and a variety of land-, sea-, and space-based sensors, including upgrades to three existing early warning radars located in Clear, Alaska; Thule, Greenland; and Fylingdales, Great Britain (*see* Early Warning).

Initial reports regarding the performance of the Patriot missile defense system in the war with Iraq in March and April 2003 indicated a high degree of success in intercepting shorter-range (and slower) Iraqi missiles, although serious questions have arisen related to several friendly-fire incidents wherein Patriot missiles downed allied aircraft. Thus, the debate over missile defense is far from over.

—*Kerry Kartchner*

See also: Early Warning; Moscow Antiballistic Missile System; Sentinel; Space-Based Infrared Radar System; Surveillance; Theater High Altitude Air Defense; Theater Missile Defense

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MISSILE DEFENSE AGENCY (MDA)

See Ballistic Missile Defense Organization

MISSILE GAP

Estimates that the Soviet Union would create a missile gap and gain strategic advantage by surpassing the United States in the production of intercontinental ballistic missiles (ICBMs) sparked considerable public and official concern during the late 1950s and early 1960s. The Soviet launch of Sputnik on October 4, 1957, was the proximate cause for missile-gap fears that did not subside until well into the John F. Kennedy administration's term in office. In reality, a reverse missile gap developed during the early years of the missile age because the United States deployed many more ICBMs than the Soviet Union until the late 1960s.

Americans were concerned about their potential vulnerability to rapid or surprise nuclear attack during the 1950s because of their memories of Pearl Harbor, developments in nuclear weapons and missile delivery systems, lack of hard strategic intelligence, the Dwight D. Eisenhower administration's defense policies, and domestic politics. Fears of a bomber gap developed after Western military attachés observed a greater than expected number of intercontinental M-4 Bison bombers during a Moscow air show in July 1995. After Sputnik, bomber gap fears were replaced by greater fears about the apparent failure of American science and the terrifying threat of nearly instantaneous attack from ICBMs. Congressional Democrats, in particular, used the missile gap to attack Eisenhower's "New Look" and massive retaliation defense policies and were aided by the sober assessments in the Gaither Report, which was completed for the National Security Council in November 1957. The missile gap and American defense preparedness in general were significant issues in the 1960 presidential campaign. The missile gap issue dissipated, however, after analysis of photos of the U.S.S.R. produced by U-2 aircraft and, especially, CORONA reconnaissance satellites in the early 1960s revealed far fewer ICBMs than had been estimated.

—*Peter Hays*

See also: Cold War

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MISSILE TECHNOLOGY CONTROL REGIME (MTCR)

The Missile Technology Control Regime (MTCR) is a set of guidelines regulating the export of ballistic and cruise missiles, unmanned aerial vehicles (UAVs), and related technology for those systems capable of carrying a 500-kilogram payload at least 300 kilometers.

On April 16, 1987, Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States established the MTCR to govern the export of missiles and related technology. The regime is an informal, voluntary arrangement rather than a treaty or international agreement. It consists of a set of common export policies applied to a list of controlled items. Each member implements its commitments in the context of its own national export laws. In addition to the states that have formally joined the MTCR, a number of countries unilaterally observe or adhere to the guidelines.

The MTCR guidelines cover ballistic missiles, space launch vehicles, sounding rockets, cruise missiles, drones, and remotely piloted vehicles. The guidelines explicitly state that the regime is "not designed to impede national space programs or international cooperation in such programs as long as such programs could not contribute to delivery systems for weapons of mass destruction." When announced in 1987, the regime was concerned only with nuclear-capable delivery systems. In January 1993, however, the adherents extended the guidelines to cover systems capable of delivering all nuclear, biological, and chemical weapons.

The MTCR's annex of controlled equipment and technology includes equipment and technology, both military and dual-use, relevant to missile development, production, and operation. It is divided into Category I and Category II items. Export of Category I items—including complete rocket systems, cruise missiles, and unmanned aerial vehicles, specially designed production facilities for these systems, and certain complete subsystems—is subject to a presumption of export denial. Category II items—such as propellants, structural materials, test equipment, and flight instruments—may be exported at the discretion of the MTCR partner government on a case-by-case basis for acceptable end uses. They also may be exported after the exchange of government-to-government assurances, which provide that they not be used on a missile system capable of delivering a 500-kilogram payload to a range of at least 300 kilometers.

MTCR partners hold an annual plenary meeting chaired on a rotational basis. Inter-sessional consultations take place monthly though Point of Contact meetings in Paris. The MTCR also undertakes outreach activities to nonpartners.

The current members of the MTCR are Argentina, Australia, Austria, Belgium, Brazil, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Russia, South Africa, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. Several others, including China, Israel, and Ukraine, have pledged to adhere to the export control regime but have not been invited or do not seek to become members.

—*Tom Mahnken*

See also: Nonproliferation

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MIXED OXIDE FUEL (MOX)

Mixed oxide fuels are mixtures of uranium and plutonium oxides used in reactor operations. These mixtures are often referred to as MOX. The plutonium that makes up MOX comes from two main sources: fuel reprocessing and weapon disassembly. The uranium content of MOX is depleted uranium. The primary use of MOX fuel is to burn excess plutonium generated from spent fuel and disassembled weapons in conventional reactors to generate energy.

Technical Details

The limited use of mixed oxide fuels does not appreciably change the operating characteristics of a reactor. If the core of a reactor is more than 50 percent MOX, however, significant changes must be made to the core layout and to control-rod positioning within the reactor. MOX fuels enjoy an advantage over low enriched uranium (LEU) fuels in this application because concentrations of plutonium within MOX fuel rods can be very cheaply increased, whereas uranium enrichment is expensive. This issue becomes important when designing cores that require a larger initial loading of fissile material (*see* Enrichment; Low Enriched Uranium).

The plutonium that is mixed with uranium to form MOX comes from two sources. One source is spent nuclear fuel. The plutonium from spent nuclear fuel is generated in the fuel during the irradiation process. Nonirradiated LEU fuel does not contain plutonium; however, approximately one-third of the energy it produces is generated by the fissioning of plutonium. Plutonium is formed in the reactor through neutron capture by the uranium. By the end of the life of a typical fuel bundle in a thermal reactor, the fuel contains about 1 percent plutonium. This form of plutonium is commonly referred to as "reactor-grade" plutonium, where the plutonium contains more than 19 percent Plutonium 240 (Pu-240) and less than 60 percent Pu-239. Mixed oxide fuel using reactor-grade plutonium is typically 7 percent plutonium, which is roughly equivalent to 4.5 percent Uranium 235 (U-235) owing to the presence of other plutonium isotopes. About 50 metric tons of reactor-grade plutonium are produced each year in the spent fuel from the many operating reactors around the world. This rate of production adds yearly to the 1,000 metric tons that have already been produced. The vast majority of this plutonium remains held within the spent fuel.

Plutonium from disassembled nuclear weapons is typically referred to as "weapons grade" when the plutonium is at least 92 percent Pu-239. Mixed oxide fuels using weapons-grade plutonium are typically 5 percent plutonium. Spent MOX fuel that has been burned in a reactor with weapons-grade plutonium contains an isotopic distribution similar to that of spent LEU fuel. The current world inventory of weapons-grade plutonium is estimated to be approximately 200 to 270 metric tons, with the United States holding 85 metric tons and Russia holding between 100 to 165 metric tons.

All plutonium except that containing more than 80 percent Pu-238 is considered, by the International Atomic Energy Agency (IAEA), to be "direct-use" plutonium. The IAEA's position is that it is theoretically possible to build a nuclear explosive from direct-use plutonium. There are many technical challenges that must be overcome to build an explosive from anything other than weapons-grade plutonium. Among these challenges are issues of weapon reliability, useful yield, deliverable size, and storage life. An issue that further clouds this picture is that in 1962 the United States successfully tested a device that used what was referred to as reactor-grade plutonium, but what U.S. officials referred to as reactor-grade plutonium in this test contained a much higher proportion of Pu-239 than what is produced in the spent fuel of power reactors today. It is estimated that the device contained between 70 and 75 percent Pu-239, compared to about 55 percent Pu-239 produced by power reactors. The actual content of plutonium used in the test is classified and has not been released.

Current Status

Mixed oxide fuel was originally developed to run in fast reactors, but in 1963 it saw its first use in a thermal reactor. Since that time, MOX has been seen more and more in terms of the opportunities it offers, both to recover energy from spent nuclear fuel and from surplus weapons plutonium and to reduce the volume of waste produced by nuclear power plants as well as the stockpiles of weapons material.

All modern light-water reactors can use a 30 percent MOX fuel load without significant modification to their core assembly. At least thirty-two European reactors are licensed to use 30 percent MOX in their cores. The United States and Russia have recently signed agreements to each convert 34 metric tons of weapons-grade plutonium into MOX fuel. Both countries are in the process of licensing reactors to burn this fuel. Japan is planning to use MOX in as many as one-third of its reactors in the near future. In addition to using MOX in thermal reactors, France and Russia are using it as a primary fuel source for their fast reactors. About 8 to 10 metric tons of plutonium are converted to MOX and used each year. Currently, MOX is produced in two facilities in France, one in Belgium, and one in the United Kingdom. European MOX production generates about 300 metric tons of MOX per year using approximately 20 metric tons of plutonium.

The use of MOX fuel is expected to increase in the near future until the production of MOX and the use of MOX are in balance. The United States and Russia are expected to build MOX fabrication facilities by 2005. These will most likely be located at the Savanna River Facility in the United States and at the Mayak facility in Russia. These plants are expected to produce together 40 metric tons of MOX per year using 2 metric tons of weapons-grade plutonium. In the short term worldwide, processed plutonium stockpiles are expected to increase before this balance is reached. In the future, the production and use of MOX should increase as the use of reprocessing becomes the standard practice within the nuclear fuel cycle.

—C. Ross Schmidtlein

See also: Depleted Uranium (U-238); Fast Breeder Reactors; Light-Water Reactors; Plutonium; Uranium

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MOBILE ICBMS

To increase the survivability of land-based intercontinental ballistic missiles (ICBMs), military planners have always turned to mobility in order to complicate the calculations of an attacker. For the Soviet Union, development of mobile ICBMs was slow until the late 1960s owing to concerns about command and control and the ability to maintain positive control of Soviet missiles under all circumstances. Lack of communications links were an additional Soviet concern. In the United States, high operating costs and the need to operate systems over enormous expanses of land limited interest in mobile missiles. The U.S. Air Force pursued the rail-mobile Minuteman option in 1960, which would have been deployed at Hill Air Force Base, Utah, but for budgetary reasons Secretary of Defense Robert McNamara canceled the planned procurement of additional Minuteman ICBMs, which eliminated the need for the deployment scheme. As the accuracy of ICBMs improved, creating concerns about the survivability of ICBMs deployed in fixed silos, both superpowers revisited the issue of deploying mobile ICBMs.

The Soviets first attempted to use a tank chassis as a transporter for the SS-15 in 1968. After discovering that vibration of the chassis caused missile component failures, they canceled the system after ten test flights. After reviewing its options, the Soviet Strategic Forces decided that a truck chassis was a better vehicle than a tank chassis as a missile transporter, offered better road speeds, was relatively easy to maintain, and created fewer vibration problems. The SS-16 system that emerged in 1972 was concealable, highly mobile, and successful. It also became one of the major stumbling blocks in superpower arms control talks. The United States could not detect the missile launchers using reconnaissance satellites and tried to have mobile missiles banned. The SS-16 was specifically banned in the treaty resulting from the Strategic Arms Limitation Talks (SALT I), although the Soviets kept the missile in their inventory in violation of the treaty. It was eventually withdrawn from service when better systems were ready for deployment.

After the SS-16 was decommissioned, the designs were used in the highly successful SS-20 intermediate-range ballistic missile (IRBM) that entered the Soviet arsenal in the 1970s. Soviet planners also decided that they required a secure second-strike capability and eventually deployed the road-mobile SS-25 and the rail-mobile SS-24 ICBMs. The SS-25 carried a single warhead, while the SS-24 carried ten multiple independently targetable reentry vehicles (MIRVs). The SS-24 was deployed on missile trains that carried three missiles, their launchers, support equipment, and security railcars. These missile trains usually patrolled for about five days out of garrisons that were situated along the Trans-Siberian Railroad. In order to keep its defense posture as other strategic arms treaties entered into force, Russia replaced the SS-25 with the SS-27, another road-mobile missile.

During the Jimmy Carter administration and the early Ronald Reagan years, a debate raged in U.S. policy circles about how to deploy the new U.S. ICBM that was under development. It made little sense to deploy the new missile in fixed silos because these could easily be destroyed by Soviet nuclear forces. Shuttling the missile among multiple shelters was suggested, but creating this giant "shell game" would have been enormously expensive and required enormous amounts of land. A "dense pack" scheme was suggested that relied upon fratricide among incoming warheads to prevent the new land-based missiles from being destroyed quickly in a Soviet nuclear attack (*see* Dense Pack). Eventually, two mobile systems were developed to reduce the vulnerability of U.S. land-based ICBMs. The MX Peacekeeper would be deployed in rail garrison in times of crisis, and U.S. missile trains would move on to U.S. civilian railroads to complicate Soviet efforts to destroy them. The Midgetman, a road-mobile single-warhead missile, also was under development. Both deployment schemes were canceled at the end of the Cold War.

—Gilles Van Nederveen

See also: Midgetman ICBM; Peacekeeper Missile

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MORATORIUM

A moratorium is a legal or legislative action for the temporary suspension or prohibition of an ongoing or planned activity. In the world of nuclear weapons, the term usually refers specifically to the suspension of nuclear weapons testing.

On October 31, 1958, U.S. President Dwight D. Eisenhower declared a unilateral moratorium on nuclear testing. The United Kingdom and the Soviet Union also voluntarily observed this informal nuclear test moratorium until September 1, 1961, when the Soviet Union conducted a series of nuclear tests. On September 15, 1961, the United States resumed testing of nuclear weapons at the Nevada Test Site.

For political purposes, the Soviet Union observed unilateral nuclear testing moratoriums during three separate time periods: December 1962 to March 1964; August 1985 to October 1987; and November 1989 to October 1990.

In October 1991, Soviet President Mikhail Gorbachev declared a unilateral nuclear testing moratorium. On October 2, 1992, U.S. President George H. W. Bush signed the Hatfield-Exon-Mitchell Amendment, which imposed a nine-month nuclear test moratorium. U.S. President Bill Clinton extended the moratorium several times before signing the Comprehensive Test Ban Treaty (CTBT) on September 24, 1996. This treaty precludes the necessity for further nuclear testing moratoriums. However, the U.S. Senate has not ratified the treaty and it has therefore not entered into force.

A nuclear test moratorium is an instrument of disarmament because over time it reduces confidence in the reliability of one's nuclear arsenal and diminishes a state's ability to build nuclear weapons or update an existing arsenal to meet new requirements. Newly designed weapons may require testing. The George W. Bush administration, while agreeing to adhere to the specifications of the nonratified CTBT, also refused to permanently surrender the option of eventually testing new U.S. weapons.

—Don Gillich

See also: Comprehensive Test Ban Treaty; Disarmament; Nuclear Test Ban

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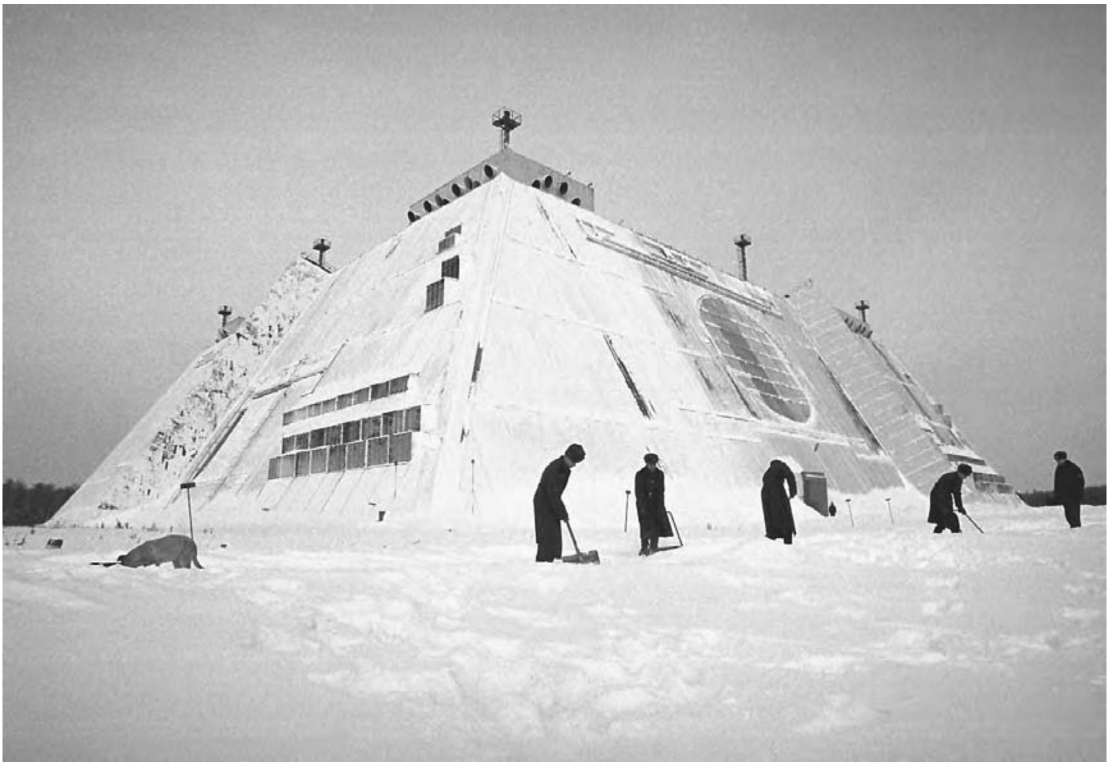
MOSCOW ANTIBALLISTIC MISSILE SYSTEM

The Russian antiballistic missile (ABM) system surrounding the capital of Moscow was the only active ABM system in the world until the United States commissioned its missile defense system in Alaska in October 2004. Soviet research into antimissile defense started in 1948 but did not begin in earnest until 1955, when a special antimissile test site was established near Sary Shagan on Lake Balkash in Central Asia. In tests conducted at the site, rockets, usually SS-3 or SS-4 medium-range ballistic missiles, were launched toward Sary Shagan from Kapustin Yar near Volgograd. These rockets served as targets for the antiballistic missile systems being tested at Sary Shagan. To demonstrate that antiballistic missile components could withstand a nuclear blast environment and operate in that environment, nuclear tests also were conducted at the site (*see* Missile Defense).

Construction of the first Soviet ABM system, called ABM-1 (or "Galosh") by the West, began in October 1962. Eight separate complexes were constructed in a ring about 45 nautical miles from the center of Moscow, but only four eventually became operational as part of the ABM-1 system. The interceptor missiles were kept in aboveground, reloadable launchers. Sixty-four exoatmospheric missiles became operational in 1967. They had a 200-mile range and carried a relatively large nuclear warhead intended to detonate in the path of incoming U.S. nuclear-armed reentry vehicles. By 1976, these first



The Moscow ABM system's missile detection center, the "Don 2N" site, January 2000. (Caw/Str Reuters/Corbis)

missiles had been replaced by variants that could start and stop their rocket motor so that the system radars could discriminate between warhead, chaff, and decoys. ABM-1 relied on four battle management radars at each of the four missile sites (named "Try Add" by the West) and two large phased-array radars for battle management near Moscow ("Dog House" and "Cat House"). Six early-warning radars located on the intercontinental ballistic missile (ICBM) and submarine-launched ballistic missile (SLBM) approach corridors to the Soviet heartland provided early warning to the Moscow system.

Soviet ABM deployments continued throughout the Cold War. The ABM-2 was a road-mobile system that never reached operational status. The current system is designated ABM-3. It is similar to the old U.S. Safeguard system, which employed one type of interceptor to attack incoming warheads outside the atmosphere and a shorter-range missile to engage incoming warheads in their terminal phase. The Soviets also developed a high-acceleration missile similar to the U.S. Sprint. Deployed in 1984, it was modified to improve its intercept capabilities against the U.S. Army's Pershing II missile stationed in West Germany. The SH-08 Gazelle was designed for endoatmospheric interception with a range of 80 miles and a 1-kiloton warhead. The SH-11 Gorgon is an exoatmospheric interceptor with a 200-mile range. Currently there are thirty-six SH-11 Gorgons, and sixty-four Gazelles are deployed around Moscow in underground silos at eight sites.

The most visible part of the system is the Pill Box phased-array radar at Balabanovo that serves dual roles as a surveillance and engagement radar. A new family of phased radars, Pechora, also was deployed in the mid-1980s to improve early warning for the ABM-3 system. Some of these radars were located outside of Russia in the newly independent republics, so following the collapse of the Soviet Union, Russia was forced to build radars at new sites or pay those governments for access.

One system that caused much controversy during Ronald Reagan's term as president in the United States was the Soviet SA-12B surface-to-air missile system. This system was primarily designed to intercept aircraft but probably also had some capability against tactical and intermediate-range missile warheads. It has a 100-mile range and is equipped with a high-explosive warhead. The Russian Army currently deploys mixed SA-12 battalions that contain both the shorter-range SA-12A and the longer-range SA-12B, plus radars and support equipment. The exact ABM abilities of the SA-12B are unknown but are probably similar to those of the U.S. Patriot system.

—*Gilles Van Nederveen*

See also: Safeguard Anti-Ballistic Missile System

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MOSCOW TREATY

See Strategic Offensive Reductions Treaty

MULTILATERAL NUCLEAR FORCE

The idea for a European Multilateral Force (MLF) emerged in the early 1960s at about the same time that the North Atlantic Treaty Organization (NATO) was considering the introduction of a new flexible-response strategy. The concept was seen as a way for NATO members to share nuclear responsibility by deploying nuclear weapons on naval vessels that would be manned by crews drawn from all member nations (*see* North Atlantic Treaty Organization).

The thought of equipping NATO allies with nuclear weapons was initially considered by U.S. strategists during the 1950s. By the early 1960s, in an effort to slow nuclear proliferation and to increase the credibility of the U.S. nuclear guarantee to NATO, the John F. Kennedy administration offered to create an MLF, a surface or submarine fleet manned by NATO crews equipped with nuclear-armed Polaris missiles. Some observers, including U.S. Secretary of Defense Robert McNamara, however, were concerned that the MLF might not fit into the new NATO strategy of flexible response, which demanded centralized decision-making to fine-tune escalation from conventional to nuclear war.

The West German government supported the U.S. proposal, but most NATO members were ambivalent about the MLF. British officials were concerned about the potential cost of the concept. In 1965, the British proposed an Atlantic Nuclear Force (ANF), which would be made up of submarine-based Polaris ballistic missiles maintained by the United States and the United Kingdom. The British ANF proposal reduced the momentum behind the MLF, much to the annoyance of the West German government. The MLF was abandoned by the Lyndon B. Johnson administration in favor of something amounting to the British ANF proposal. Throughout most of the Cold War, the U.S. and British navies dedicated part of their ballistic missile submarines to NATO contingencies.

—*Andrew M. Dorman and James J. Wirtz*

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MULTIPLE INDEPENDENTLY TARGETABLE REENTRY VEHICLE (MIRV)

First deployed in the 1970s, the multiple independently targetable reentry vehicle (MIRV) revolutionized the capabilities of nuclear-armed ballistic missiles by enabling a single missile to destroy several targets. As accuracies improved, this prompt hard-target kill capability threatened the crisis stability of superpower nuclear deterrence. Widely remembered as the most dangerous technological innovation after the introduction of the intercontinental ballistic missile (ICBM), MIRVing undermined the achievements of the first arms control treaties and contributed to new superpower tensions. Although restricted in 1991 by the Strategic Arms Reduction Treaty (START I), smaller numbers of MIRVed missiles continue to be deployed by Russia and the United States. They also have been deployed by Britain and France.

Progressive increases in launcher control mechanisms, as well as refinement of missile accuracy, reentry-vehicle design, and warhead size enables individual launchers to carry three to ten or even more nuclear warheads and to target these warheads against multiple targets within the "MIRV footprint" (that is, the geographic area within the range of warheads on one missile). Although individual warheads deployed in this way are smaller in size and destructive power than the large unitary warheads they replaced, their greater accuracy and numbers actually increased the ability of the superpowers to guarantee the destruction of more targets.

Individually too small to insure the destruction of geographically large targets such as major cities, MIRVs are more suitable for attacks on specific targets, especially ballistic missile silos and command and control facilities. With their capability to engage such counterforce targets, MIRVs introduced unprecedented potential for preemptive nuclear war, enabling an attacker to use a small proportion of their missiles to eliminate a large share of their adversary's nuclear missiles (*see* Counterforce Targeting). By threatening the survivability of much of the victim's retaliatory capability, it was argued, MIRVs could weaken the victim's ability to retaliate through a disarming first strike, potentially reducing the surviving force below the threshold at which retaliation was credible. By threatening to undermine the stability of superpower deterrence, MIRVs raised the possibility of new vulnerabilities and instability in times of crisis (*see* Crisis Stability; Deterrence).

MIRV technology originated with development of a special stage, or "bus," to launch several orbital satellites with a single launcher. The United States started full-scale development of the three-stage Minuteman III ICBM with three warheads in 1966. Initial operational capability with 170-kiloton warheads was achieved in 1970. The Soviet Union began full-scale development of its SS-18 ICBM in 1969. Although this initially was fielded with a unitary warhead, in 1976 the Mod-4 version was tested with ten warheads.

Whereas the Minuteman III was justified by the U.S. Air Force as an incremental improvement in warhead and reentry technology, the Soviet SS-18 was seen by conservative American analysts as proof of Soviet planning for a disarming first strike. Anxieties about a "window of vulnerability," provoked by Soviet SS-18 deployments, were an important ingredient in Ronald Reagan's successful 1980 presidential campaign.

MIRV deployment was tightly regulated by START I in 1991 and banned completely by START II, signed in 1993. The failure to ratify START II and its replacement by the subsequent Moscow Treaty of 2002 effectively permits MIRVing within overall warhead ceilings. The United States continues to deploy MIRVed Trident II submarine-launched ballistic missiles, and Russia emphasizes MIRVed SS-19 ICBMs as the dominant element of its nuclear forces. China was believed to have perfected the basic capability for MIRVing by the mid-1990s, although there is no evidence that the Chinese military has conducted operational testing of MIRVs.

—*Aaron Karp*

See also: Ballistic Missiles; Reentry Vehicles; Strategic Arms Reduction Treaty

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MULTIPLE LAUNCH ROCKET SYSTEM (MLRS)

The multiple launch rocket system (MLRS) fires salvos or single rounds of artillery rockets. The simplest form of contemporary missile weapon, the artillery rocket is a direct descendent of thirteenth-century Chinese rockets, Indian rockets of the Anglo-Mysore wars of 1780–1799, and William Congreve's rockets of the Napoleonic wars. Better propellants and aerodynamics allowed the major powers to develop more powerful versions beginning in the 1930s. An early success was the Soviet BM-13 Katyusha, a truck-mounted MLRS battery used widely in World War II, also called "Stalin's Organ."

Since then, the range of artillery rockets has increased from 6 kilometers to 70 or more in current models such as the American MLRS, the Chinese WS-1, and the Russian Smerch. As unguided weapons, they lack accuracy, but their low cost and their ability to be fired in large volleys compensate for this drawback. Guided versions with longer range also have been developed to serve more specialized missions, such as artillery suppression. Smaller models, especially the Chinese-made Type-63, have become popular as long-range weapons for guerrilla forces and terrorists.

Combining small payloads with adequate range and low cost, artillery rockets are well suited for delivery of chemical and biological warheads. Even when conventionally armed, they offer an asymmetric mass destruction capability. In Lebanon, Hezbollah, an anti-Israeli terrorist group, had reportedly accumulated 8,000 to 9,000 rockets as of late 2002, enough to cause massive damage. In

1994, thousands of artillery rockets were used by several warring factions to destroy much of Kabul. Hamas, the main Islamic group in the Palestinian territories, improvised designs of its own in 2002–2003 that were subsequently used for attacks on Israel from Gaza.

The Israeli Defense Forces and the U.S. Army are developing active defenses to shoot down artillery rockets. The technical ability of lasers to perform this mission was proven by tests in 2002–2003, although design of a rugged, affordable, and easily transportable interceptor system remains to be achieved.

—Aaron Karp

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MUTUAL ASSURED DESTRUCTION (MAD)

Mutual assured destruction (MAD) is a situation in which two or more states possess a secure second-strike capability allowing them to destroy their adversaries even after absorbing a major nuclear attack. During the Cold War, MAD was depicted as a stable deterrence relationship by many theorists who believed that the threat of massive retaliation could prevent each side from initiating a surprise nuclear first strike. They therefore recommended having enough survivable nuclear weapons to assure the adversary's destruction as a modern society in a retaliatory response. These theorists often assumed that such a second strike would target cities in a strictly punitive retaliation with no specific military objective other than the complete annihilation of the attacker's nation. Many believed that the possession of a secure second-strike capability was the only sure means of deterring a surprise nuclear attack and that MAD was thus the inescapable basis of crisis stability in a Cold War environment dominated by two heavily armed superpowers. The acronym became an ironic metaphor for the belief that the destructiveness of war has reduced the danger of war.

In the mid-1960s, as Soviet nuclear power grew to rival that of the United States, U.S. Secretary of Defense Robert S. McNamara came to believe that a mutual ability to assure the destruction of the opponent's society in a second strike provided the United States and the Soviet Union with the strongest possible motive to avoid nuclear war. This belief that the Soviet Union shared an assured destruction strategy gave rise to the term "mutual assured destruction" and was used to justify opposing the deployment of antiballistic missile (ABM) systems that would undermine either side's ability to hold the other's society at risk.

MAD did not describe the actual targeting strategy followed by either the United States or the Soviet Union, both of which pursued more operationally oriented counterforce targeting strategies, although U.S. war plans called for withholding a "strategic reserve," and the strike plans for these reserves came close to resembling a MAD targeting doctrine (*see* Counterforce Targeting; Countervalue Targeting). Nevertheless, many believed that MAD described an existential reality that neither superpower could really transcend no matter what its actually targeting strategy was, as long as the nuclear arsenals of the two sides far exceeded what was needed for strictly military targeting objectives, and that as a last resort, one or both sides would ultimately respond to a nuclear escalation with an all-out attack on the other's cities (*see* Escalation).

Most criticisms of MAD revolved around its credibility, or lack thereof. Some asserted that no one would actually believe that either side was politically capable of unleashing an all-out attack against urban-industrial centers, especially if it came in the aftermath of a series of nuclear exchanges that had already left most of both sides in ruins. Moreover, religious authorities noted that it was not morally sustainable to threaten to do what one was morally forbidden to do, and that a strategy of assured destruction violated the most fundamental precepts of the just war tradition.

Despite these criticisms and the end of the Cold War, many continue to believe that as long as the United States and Russia maintain large residual nuclear arsenals, a condition of MAD will exist between them, and that such a condition could come to include China in the near future.

—Kerry Kartchner

See also: Assured Destruction; Cold War; Deterrence; Second Strikes; Superiority

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MX ICBMS

See Peacekeeper Missile

N

NAGASAKI

Nagasaki is a commercial port city on the southern Japanese island of Kyushu that was the site of the second U.S. atomic attack against Japan. The attack occurred on August 9, 1945, three days after the first nuclear bomb ever to be used in warfare was dropped on Hiroshima on August 6. On September 2, 1945, Japan surrendered and World War II came to an end.

Nagasaki was the site of the first European influence in Japan. Portuguese traders and missionaries established a community there in the late 1500s, followed by the Dutch. Even during the shogunate period of "enclosure," Nagasaki remained open to foreigners for trade, although all Western religious activity was banned. Because of its clay deposits, the area has long been a center for ceramics, including pottery and fine china, and its commercial port made Nagasaki a more cosmopolitan area than many other parts of Japan. The Giacomo Puccini opera *Madama Butterfly* is set in Nagasaki.

During World War II, the U.S Manhattan Project developed atomic bombs for use by U.S. forces. Two types of bombs were developed: a gun-type device that used uranium to create a critical mass, and an implosion device that used plutonium as its fissile

The remains of a Catholic cathedral, Nagasaki, August 1945. (National Archives) material. By the summer of 1945, one bomb of each type was available for use against Japan (*see* Criticality and Critical Mass; Fission Weapons; Gun-Type Devices; Implosion Devices; Manhattan Project; Plutonium; Uranium).

U.S. war plans had included an invasion of the Japanese home islands as a means to force the surrender of the Japanese government. The successful, though costly invasion of Okinawa (which resulted in 49,151 U.S. fatalities) was to be followed by the invasion of Kyushu by 190,000 U.S. troops. It was estimated that the invasion of Kyushu would result in 69,000 U.S. fatalities. President Harry S. Truman determined to delay a home island invasion and use aerial atomic bombing to save U.S. troops and Japanese civilian lives.

Nagasaki was not among the original target cities selected for nuclear destruction as a means to force a Japanese surrender. It was substituted for Kyoto when Secretary of War Henry L. Stimson moved to protect Kyoto's antiquities. Nagasaki was selected because of its large commercial harbor and four large Mitsubishi war production plants.

The bomb dropped on Nagasaki was "Fat Man," an implosion weapon that used plutonium 239 (Pu-239) produced in nuclear reactors at Hanford, Washington (*see* Fat Man; Hanford, Washington). It was dropped from a B-29 named *Bockscar.* Due to weather problems, the original commercial target site was missed and the bomb was dropped over Nagasaki's industrial center. The plutonium bomb created a blast equivalent to 20,000 tons of TNT. Fat Man was more powerful than the gun-type device dropped on Hiroshima, "Little Boy" (*see* Hiroshima; Little Boy), and the hills surrounding Nagasaki concentrated the blast produced by the bomb. The hills also served to protect some of Nagasaki's population from radiant heat and ionizing radiation, leaving about 25 percent of the population dead or injured. The area of destruction was one and a half square miles. About 23,753 people were killed and a similar number were injured. The topography prevented a firestorm from developing and localized the direct effects of the blast, resulting in less public panic than in Hiroshima. The industrial damage was high, partly owing to the inadvertent targeting of the industrial zone, leaving 68 percent of the non-dockyard industrial production destroyed.

The area of the explosion has been rebuilt as a modern city center. There is a museum and park memorializing the lives lost in the attack. The museum is less politicized than the larger and more famous one in Hiroshima, with descriptive materials confined to the events in Nagasaki.

—Frannie Edwards

See also: Tinian

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NATIONAL COMMAND AUTHORITY

The individuals within the U.S. government possessing the ultimate responsibility for decisions to use nuclear weapons and the constitutional authority to direct the U.S. Armed Forces are collectively called the National Command Authority (NCA). The term is drawn from the Unified Command Plan, a classified document that regulates military procedures and lines of authority. The individuals traditionally designated as the NCA are the president and the secretary of defense, and upon their death or incapacitation their successors as set forth in the Constitution and the Presidential Succession Act of 1947. The process by which the NCA might order the use of nuclear weapons has not been discussed publicly and is classified. In 1974, the House Foreign Affairs Committee stated that no military officer may initiate the use of nuclear weapons unless authorized by the president or his successor. Additionally, by law no one else in the chain of command has the authority to order the use of nuclear weapons simply on their own initiative. The president, on the basis of personal preference, decides procedures for NCA operations. Overall authority to use U.S. nuclear weapons rests with the NCA.

In 2002, U.S. Secretary of Defense Donald Rumsfeld stated that the term "National Command Authority" would be discontinued. Currently, on Department of Defense documents, the term "National Command Authorities" has been replaced with the words "President" and/or "Secretary of Defense."

—Laura Fontaine

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NATIONAL EMERGENCY AIRBORNE COMMAND POST (NEACP)

The growth of the Soviet nuclear threat and the resulting fear that the U.S. president and secretary of defense could be killed in Washington, D.C., before ordering a retaliatory strike led the U.S. Air Force in 1962 to establish the National Emergency Airborne Command Post (NEACP, pronounced "kneecap"). For this purpose, the Air Force converted four KC-135A tankers, equipping them with extensive communication suites. Designated EC-135J Nightwatch, these aircraft were designed to give the president, the secretary of defense, and other members of the National Command Authority (NCA) the ability to command nuclear forces in the event that ground command posts were destroyed. From the aircraft, a member of the NCA had access to the digital codes required to unlock the U.S. nuclear arsenal and launch a nuclear strike (*see* National Command Authority).

In 1974, the original EC-135s were replaced with four Boeing 747-200s converted to the NEACP role and given the military designation E-4B. Modified to carry thirty different communications systems (VLF to SHF) and up to 114 crew members, the E-4Bs also were hardened to withstand the electromagnetic pulse created by a nuclear blast. Originally based at Andrews Air Force Base (AFB) outside of Washington, D.C., the aircraft were moved to Offutt AFB in Nebraska in the 1980s to keep them safe from submarine-launched ballistic missile strikes. The aircraft now have alternate bases throughout the United States and frequently deploy with the president overseas to ensure reliable and secure communications. In August 1994, the E-4Bs flying the NEACP mission were renamed National Airborne Operations Center (NAOC) to reflect the fact that the Federal Emergency Management Agency (FEMA) could now also use the airborne command post to respond to national disasters.

—*Gilles Van Nederveen*

See also: Strategic Air Command/Strategic Command

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NATIONAL STRATEGIC TARGET LIST

The National Strategic Target List (NSTL) is one of the most closely guarded U.S. military secrets. A prioritized list of identified targeting points and planning functions, it is used in conjunction with the National Strategic Targeting and Attack Policy (NSTAP) and the Nuclear Weapons Employment Policy (NUWEP). During the Cold War, the Joint Strategic Target Planning Staff (JSTPS) of the Strategic Air Command developed and maintained the NSTL. The Joint Planning Staff uses the list to assign weapons to various functions according to availability and effectiveness for particular tasks. The NSTL was developed to provide for the integration of committed forces for the attack of a minimum list of targets, the destruction of which would accomplish given objectives. Additionally, military planners use the NSTL in their task of processing and analyzing target data. President Dwight D. Eisenhower approved the Strategic Air Command's request to prepare the National Strategic Target List on August 11, 1960.

Since the 1940s, target lists have been kept classified because they provide information concerning current target selection criteria, strategy, intelligence sources and methods, and nuclear weapons effects. U.S. nuclear war plans have included a wide range of target types: military forces, bases, installations, and stockpiles; economic and industrial centers; political and administrative centers; and, after 1950, Soviet nuclear forces. In 1961, the Single Integrated Operational Plan (SIOP) introduced greater flexibility into the U.S. strategic nuclear war plans. The NSTL has been divided into various target sets to provide the National Command Authority (NCA) with a range of options, such as withholding attacks against urban-industrial areas (*see* National Command Authority).

Due to the classified nature of the NSTL, target sets are not known or shared publicly. The Joint Strategic Capabilities Plan from 2000 (an unclassified document) offers broad guidance to combatant commanders planning nuclear operations. The Joint Strategic Plan does not identify the NSTL, however it does explain a few points concerning tactical planning. For example, combatant commanders must comply with several operational constraints when preparing plans for nuclear weapons employment options: (1) Nuclear weapons use is not authorized except in response to an enemy nuclear attack, although the United States reserves the right to use nuclear weapons first; (2) every effort will be made to limit attacks against populated areas; (3) weapon yields will be limited to those only essential in accomplishing the mission; and (4) the allocation of nuclear weapons and handling and storage of these weapons will follow approved plans.

Although the U.S. Strategic Command, the successor to SAC, has increasingly turned to adaptive planning, rather than the deliberate planning that lay behind creation of the SIOP, the United States continues to use the National Strategic Target List in determining nuclear weapons objectives.

—*Laura Fontaine*

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NATIONAL TECHNICAL MEANS

The term "national technical means" (NTM) was chosen by the United States and the Soviet Union during the Cold War to avoid the term "espionage" when describing efforts to monitor arms control compliance. To verify compliance with strategic arms limitation agreements, the United States and Soviet Union agreed to employ nonintrusive methods of treaty verification. The NTM verification network included satellite observation as well as terrestrial sites located outside each superpower's national boundaries. On-site arms inspections were not considered a viable alternative to NTM because Soviet officials believed that as a closed society, they had more to lose than did an open society like the United States in allowing inspectors free access to their territory. Soviet officials also refused to allow aerial overflights (often referred to as Open Skies proposals) as a confidence-building and arms control verification measure during the 1950s and 1960s, leaving satellites and electronic eavesdropping sites located outside national boundaries as the preferred method of arms control verification.

NTM can include photoreconnaissance satellites, radar, and signal-collection facilities located on aircraft, ships, satellites, and ground stations. These monitoring systems and the information-processing capabilities that support them are sophisticated and deployed across the globe. National technical means provide generally high confidence that significant cheating on Cold War arms control agreements will be detected and helped shift the political balance in the United States in support of arms control.

At times during the Cold War, NTM became a significant domestic political issue in the United States. In 1980 during the Carter administration, for example, verification of the treaty resulting from the second round of Strategic Arms Limitation Talks (SALT II) became a stumbling block for treaty ratification in the U.S. Senate. Critics of the SALT II Treaty believed that the loss of monitoring stations in Iran following the fall of the shah in 1979 hampered America's ability to verify Soviet compliance with the treaty. These stations were critical to intercepting the telemetry generated by Soviet intercontinental ballistic missiles (ICBMs) as they flew across their test ranges in Central Asia to their impact points in the Soviet Far East. President Jimmy Carter tried various methods of convincing the Senate that the U.S. intelligence community could verify the new SALT II Treaty. Ultimately, other nations provided U.S. intelligence access to their territory to replace lost listening stations needed to monitor Soviet telemetry data. SALT II was never ratified by the U.S. Senate, but for the most part Soviet and U.S. policymakers abided by its terms.

Although noninterference with national technical means of verification was addressed in the SALT treaties, Soviet officials sometimes failed to adhere to the spirit, if not the letter, of those agreements. Members of the Ronald Reagan administration probably had the greatest doubts about the ability of the U.S. intelligence community to verify compliance in light of the spotty Soviet track record on such matters. The Reagan administration charged that the Soviets encrypted telemetry, which was a serious impediment to verification and a violation of arms control specifications. There also were charges that the Soviets were camouflaging and concealing launchers. Soviet officials countered these charges by claiming that U.S. environmental shelters over Minuteman silos were concealment measures and that the United States had exceeded its authorized launcher limits when Minuteman silos were modernized. The angry exchange led the United States to demand that any future arms control agreements would have to include more extensive verification measures: on-site inspections, data-exchange challenge inspections, and cooperation with NTM observation.

No other state has matched U.S. and Russian investment in national technical means, which remains important today. Verification of several treaties, especially those concerning threshold and nuclear test bans, still relies on seismic stations and satellites.

—*Gilles Van Nederveen*

See also: Arms Control; Open Skies Treaty; Reconnaissance Satellites; Strategic Arms Limitation Talks; Strategic Arms Reduction Treaty; Strategic Arms Reduction Treaty; Verification

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NEGATIVE SECURITY ASSURANCES (NSAs)

Negative security assurances (NSAs) are statements made by declared nuclear weapons states not to use nuclear weapons against non–nuclear weapons states subject to certain conditions. The best description of NSAs is contained in the 1995 statement of U.S. Secretary of State Warren Christopher: "The United States reaffirms that it will not use nuclear weapons against non-nuclear-weapon States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons except in the case of an invasion or any other attack on the United States, its territories, its armed forces or other troops, its allies, or on a State toward which it has a security commitment, carried out or sustained by such a non-nuclear-weapon state in association or alliance with a nuclear-weapon State."

All the other nuclear weapons states have made similar statements except for China, which offered an unconditional guarantee not to use nuclear weapons against a non–nuclear weapons state. By contrast, the NSAs of the other nuclear weapons states are void if a non–nuclear weapons state is acting in concert with or allied with a nuclear weapons state. It is not clear whether China's NSA still applies to India and Pakistan, given their status as de facto nuclear weapons states. Prior to May 1998, when India and Pakistan conducted their nuclear weapon tests, Chinese officials specifically stated that China's NSA applied to both India and Pakistan even though these countries were not NPT signatories. China's NSA currently applies to Israel, another non-NPT signatory. Also, in 1996 and 1999, China issued NSAs guaranteeing that it would not use nuclear weapons against Taiwan (*see* Chinese Nuclear Weapons).

NSAs should be contrasted with "positive security assurances" (PSAs), in which nuclear weapons states pledge that they will come to the aid of a non–nuclear weapons state if that state is the victim of a nuclear attack. There is no formal treaty on NSAs, although the five nuclear weapons states have harmonized their PSAs through the adoption, in April 1995, of UN Security Council Resolution 984. China and other states in the nonaligned group at the Conference on Disarmament have pressed for a legally binding agreement on NSAs (*see* Conference on Disarmament). This has been resisted by the United States and other nuclear weapons states, which continue to believe that agreeing to such a treaty would diminish the deterrent value of nuclear weapons.

—*Guy Roberts*

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NEUTRON BOMB (ENHANCED RADIATION WEAPON)

The enhanced radiation weapon is a specialized type of small thermonuclear weapon that produces minimal blast and heat but releases a large amount of lethal radiation. Often referred to as the "neutron bomb," an enhanced radiation weapon is a nuclear warhead designed to be launched by artillery or a battlefield missile or rocket. It can be defined as a third-generation nuclear device (after fission and fusion bombs). Third-generation nuclear weapons are fusion devices that transform, select, or direct their energy in some unique way. The definition includes inertial confinement fusion, X-ray lasers, nuclear explosion–powered directed-energy weapons, nuclear kinetic-energy weapons, and enhanced microwave devices.

Based on work conducted by U.S. weapons laboratories in the 1950s, weapons designers discovered that by removing the uranium casing on a hydrogen bomb, neutrons could travel farther, and that the lethal effects of high-energy neutrons produced by the fusion of deuterium and tritium could be maximized. A 1962 test demonstrated the viability of the concept (*see* Deuterium; Tritium).

The destructive power of nuclear weapons depends on the combination of different effects. Typically, the energy released by a fission-type explosion is made up of 50 percent blast, 35 percent thermal radiation, 5 percent prompt radiation, and 10 percent residual radiation. If a pure fusion weapon were possible, then the proportions might be 20 percent blast and thermal energy, with the majority (80 percent) of a weapon's energy being released as prompt radiation. Such a pure fusion weapon would produce very little residual radiation. Research aimed at altering the balance between the fission trigger and the fusion element of the bomb, however, has only managed to increase the percentage of a weapon's yield that takes the form of radiation by a small margin.

Although many believed that the enhanced radiation artillery shell only produced radiation, it just tipped the balance between blast and radiation produced by a nuclear detonation. It was hoped, however, that this change in weapons effects would make its use appear more credible to potential Warsaw Pact opponents. This was seen as particularly necessary in the case of short-range weapons, where minimizing the effects on friendly forces was critical. Used over a battlefield, a 1-kiloton neutron bomb would kill or incapacitate people over an area twice as large as the lethal zone of a 10-kiloton standard nuclear weapon, but with a fifth of the blast (*see* Nuclear Weapons Effects; Radiation).

This third generation of nuclear weapon also prompted a surge in nuclear protest movements because many believed that the enhanced radiation weapon lowered the nuclear threshold, making nuclear weapons use more likely. Others pointed to the relative absence of long-term weapons effects (fallout) that would make the weapons appear to be more usable on battlefields adjacent to urban areas. The debate became quite shrill, with German socialist politicians referring to enhanced radiation weapons as immoral and the "perversion of humanity."

Supporters believed that the enhanced radiation weapon offered a significant improvement in the credibility of the nuclear deterrent posed by the North Atlantic Treaty Organization (NATO). The prompt radiation produced by the neutron bomb could disable troops even in tanks while reducing the risk of collateral damage and long-term radiation. By the late 1970s, NATO was preparing to deploy the neutron bomb in the form of artillery shells and Lance warheads in West Germany.

The weapon that killed humans but spared buildings unleashed a political firestorm of protest throughout Western Europe in 1977, shaking NATO to its core. What followed was one of the worst defense debacles suffered by the Jimmy Carter administration. The West German government of Chancellor Helmut Schmidt told U.S. officials that Germany could not be the only recipient of the enhanced warhead weapons. Unable to get another NATO country to take the weapons, and after a long, acrimonious debate accompanied by noisy antinuclear demonstrations, President Carter reversed his deployment and production decisions in April 1978.

Although the Soviets tested an enhanced radiation weapon, there is little evidence of the weapon's deployment by the Soviet Union. The French revealed on June 26, 1980, that they had tested a neutron device and that their enhanced radiation warhead would have been deployed on the Hades short-range ballistic missile system, which was canceled at the end of the Cold War. The Chinese also tested an enhanced radiation weapon, according to the 1999 Cox Report on U.S. national security and exports of sensitive materials and equipment to the People's Republic of China. The design details were obtained through espionage at U.S. nuclear weapons labs. Deployment data on the Chinese enhanced radiation warhead is not available.

After President Carter deferred production, President Ronald Reagan, in August 1981, ordered production of both the enhanced radiation artillery shell and the Lance warhead. These weapons were never deployed to Europe but were stockpiled in the United States. These weapons were dismantled by the late 1990s.

—*Gilles Van Nederveen*

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NEUTRONS

Atoms consist of a massive, positively charged nucleus surrounded by a cloud of negatively charged electrons. Neutrons and protons are the constituent particles of the nucleus. Neutrons are slightly more massive than protons but have no electrical charge. The neutron is of central importance in the fission process, since it is the absorption of a neutron by, for example, a uranium or plutonium nucleus that causes that nucleus to fission. A free neutron, as a neutral particle, is not affected by the positive charge of the nucleus, and so it can easily approach the nucleus.

James Chadwick received the Nobel Prize for his 1932 discovery of the neutron. This discovery completed the basic description of the atom and the nucleus and led, in 1938, to the discovery of the ability of the neutron to cause nuclear fission.

In heavier nuclei, stability requires that there be more neutrons than protons to counteract the repulsive electrical force between protons. Uranium and plutonium have many more neutrons than protons. In fission, a free neutron strikes the heavy target nucleus, bringing its rest mass energy and kinetic energy into the nucleus. This energy splits the nucleus, releasing some of the binding energy that holds the nucleus together and releasing more neutrons. These neutrons can then strike other uranium or plutonium nuclei, continuing the fission chain reaction. The chain reaction effect of neutrons causing fissions, and producing more neutrons to cause more fissions, is the fundamental process that releases energy in a controlled manner in a nuclear reactor—or in an uncontrolled manner in a nuclear bomb.

Neutrons are sometimes emitted in the radioactive decay of unstable isotopes. Neutrons, like gamma rays, alpha particles, and beta particles, can cause damage to the human body. Due to its ability to deposit great amounts of energy in the body, the neutron is a particularly damaging form of radiation (*see* Isotopes; Radiation).

Neutrons are not fundamental particles of nature but rather belong to a class of particles called "baryons." Baryons are composed of three quarks. The neutron is composed of one "up" quark and two "down" quarks.

—*Brian Moretti*

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NEVADA TEST SITE

Established in December 1950, the Nevada Test Site (NTS) has served as the nation's nuclear test site within the United States. Today, NTS personnel continue to support the nation's security requirements by maintaining a capability to test nuclear weapons. The site also has test facilities used by scientists and technicians to undertake nonfissile tests of nuclear weapons to assure the safety and security of the remaining nuclear stockpile. The test site now includes several training facilities involving counterterrorism and response to incidents involving weapons of mass destruction. Other government agencies, including the U.S. Department of Defense

Monitoring station and subsidence crater formed by an underground nuclear test at the Nevada Test Site (Huron King test, June 1980) (DTRA)

and the Defense Threat Reduction Agency, use the Nevada Test Site to support their efforts.

Scientists from the nation's nuclear weapons laboratories use the test site for experiments. At the U1a facility, scientists conduct explosive experiments on special nuclear material some 1,000 feet underground. At the Jasper facility, a 90-foot-long, two-stage gas gun targets special nuclear material at speeds up to five times the speed of sound.

The Nevada Test Site receives and disposes of low-level solid waste from the cleanup of the nation's nuclear weapons complex. In fiscal year 2003, more than 3.2 million cubic feet of material was disposed of at the Nevada Test Site's radioactive low-level waste facilities.

The NTS is large, covering 1,375 square miles. Its size, remoteness, security controls, and embedded safety culture make it well suited to support hazardous and unique scientific and military work.

—Bret Kinman

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Defense Nuclear Weapons School website, http://www.dnws.mil.

Defense Threat Reduction Agency website, http://www.dtra.mil.

NEW LOOK

"New Look" was the name used to describe the Dwight D. Eisenhower administration's defense procurement policy and military strategy. President Eisenhower was a fiscal conservative who desired a balanced federal budget and a defense strategy able to meet the demands of a long Cold War. His administration rejected the notion, embodied in the Truman Doctrine and National Security Council Document 68 (NSC-68), that defense spending needed to be targeted to meet an impending "year of maximum danger." To maintain deterrence while limiting defense spending, Eisenhower greatly increased the size of the U.S. nuclear arsenal and air force while reducing the overall size of the U.S. military, especially the army.

Eisenhower's principal defense policy document was NSC-162/2, published in October 1953. This paper defined the security problem facing the United States as "meeting the Soviet Threat" while avoiding "seriously weakening the U.S. economy or undermining our fundamental values and institutions." Eisenhower did not believe that a general war with the Soviet Union was likely; however, the possibility of "satellite conflicts" was high. Eisenhower also believed that the United States could not maintain strong enough conventional military forces to match the Soviet Union and its clients everywhere in the world. Instead, it turned to bolstering the South Koreans and the North Atlantic Treaty Organization (NATO) to contain the Soviet menace.

NSC 162/2 also articulated the concept of "massive retaliation." This concept threatened a massive nuclear attack in response to Communist military aggression, not a symmetrical conventional response in the region where the attack occurred. In an attempt to bolster the credibility of this policy, President Eisenhower himself sometimes mentioned that he considered nuclear weapons no different than conventional weapons when used on the battlefield. The intended effect of this policy was to deter the Soviets from taking any aggressive action beyond what had already occurred in Korea. By the late 1950s, the New Look and massive retaliation were the subject of much criticism. Critics, especially U.S. Army officers, believed that the New Look had led to a hollow military. They charged that the United States lacked the ground forces needed to conduct even minor operations. Massive retaliation was considered by many to be an incredible threat, especially as the Soviet nuclear arsenal grew. It was unlikely that the United States would initiate nuclear war in response to conventional military attack, especially in areas deemed peripheral (that is, anywhere other than the inter-German border). Although the New Look integrated nuclear weapons into virtually every service and weapons system available to the United States, it did have the effect of restraining U.S. defense spending.

—Bret Kinman and James J. Wirtz

See also: Cold War; Deterrence; Massive Retaliation

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NIKE ZEUS

In 1955, the U.S. Army began studying the possibility of developing a derivative of the Nike Hercules surface-to-air missile as an interceptor against hypersonic aircraft and ballistic missiles. The first version was a straightforward modification of Nike Hercules. It used the same ground command guidance as the original system and was armed with a 20-kiloton nuclear warhead. The two-stage rocket flew at a speed of Mach 4 and had a range of 200 miles. After the Russians launched Sputnik in 1957, the United States developed a completely new missile sharing only the guidance method and first-stage booster with the previous variant. Since it was designed to intercept its targets in space, it did not need large maneuvering fins. Instead, the missile featured a special third stage with small control jets to maneuver in space. The first three-stage flight of a Nike Zeus B occurred in September 1961. In July 1962, a Nike Zeus B succeeded in intercepting an Atlas intercontinental ballistic missile (ICBM) nose cone over the South Pacific Ocean.

The U.S. Army developed a sophisticated antiballistic missile (ABM) test range over the South Pacific in the late 1950s. Its primary operating base was on Kwajalein Atoll, located southeast of Hawaii (*see* Kwajalein Atoll). By the end of 1963, more than a dozen reentry vehicles had been successfully intercepted there.

From June 1963 until May 1966, a Nike Zeus B with a 50-kiloton nuclear warhead stood alert at the Kwajalein complex to intercept Soviet satellites. The U.S. Air Force also deployed the Thor intermediate-range ballistic missile in an anti-satellite interception role. The Thor was based at Johnston Island. Despite performing the same mission, the two missiles complemented each other. The Nike Zeus had a faster reaction time but a smaller range. The Thor had a slower reaction time, since it used liquid propellants, but a greater range. Because the Nike Zeus system was to use mechanical radars, however, it was deemed too slow to be effective as a missile defense weapon. Additionally, the radar system utilized by Nike Zeus could handle only a few targets at a time and was inefficient at filtering out decoys deployed by incoming reentry vehicles. As antiballistic missile research and development continued in the 1960s, the whole ABM system was redesigned and renamed Nike-X. In 1967, it was replaced by Sentinel, which used the Spartan missile to carry out ballistic missile intercepts.

—Gilles Van Nederveen

See also: Missile Defense; Sentinel; Strategic Defenses

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NO FIRST USE

A no-first-use policy is a pledge by a government not to be the first to use nuclear weapons in a conflict. For much of the Cold War, the issue for North Atlantic Treaty Organization (NATO) allies was preserving the credibility of the U.S. nuclear guarantee to the European members of NATO through its policy of extended deterrence. When the Ronald Reagan administration entered office in 1981, it took this commitment seriously and concluded that in certain circumstances the United States would have to initiate the use of nuclear weapons, as had been NATO policy since the early 1950s. To make this threat credible it would need to find some means of using such weapons without leading to mutual destruction.

In response, in 1982 four former policymakers advocated a policy of no-first-use of nuclear weapons, arguing that NATO's willingness to use weapons of mass destruction was wrong. This criticism raised fundamental questions about the credibility of NATO's policy of extended deterrence, which was predicated on the willingness of the United States to use nuclear weapons to offset Soviet conventional capabilities and raise the intensity of conflict to a level at which the Soviets could not win. In effect, these former policymakers sought to put a veto on the ladder of escalation and thus raise serious questions about NATO's strategy of flexible response, which was predicated on managing escalation. This issue was not fully resolved until the end of the Cold War, when it effectively became redundant. NATO adopted a nuclear policy of "weapons of last resort," although it never endorsed a no-first-use policy. However, the tragic events of September 11, 2001, undermined this movement toward making nuclear weapons less integrated in alliance military planning and politics. Advances in deep-earth hardened shelters for weapons of mass destruction development and storage have once again raised the question of the value of preemption as a mechanism of defense and as a means of preventing proliferation.

—Andrew M. Dorman

See also: Credibility; Deterrence; Escalation; Extended Deterrence; Flexible Response; Mutual Assured Destruction

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NON–NUCLEAR WEAPONS STATES

A non–nuclear weapons state (NNWS) is a legal distinction rather than simply a state with no nuclear weapons. Non–nuclear weapons states are defined in international law and their obligations are set forth in several documents, specifically the Nuclear Nonproliferation Treaty (NPT) of 1968.

The NPT defines non–nuclear weapons states as those that had not manufactured or detonated a nuclear weapon or other nuclear explosion device by January 1, 1967. It also stipulates that signatory NNWS agreed not to receive nuclear weapons from any source or accept control over them, not to manufacture or acquire nuclear weapons, not to seek or receive assistance in the manufacturing of nuclear weapons, and to accept international safeguard systems for all peaceful nuclear programs with the International Atomic Energy Agency (IAEA). As of

2001, IAEA safeguards agreements were in force with 142 states (*see* International Atomic Energy Agency).

Some NNWSs are signatories to regional nuclear weapons free zone (NWFZ) treaties, which obligate signing parties not to acquire or possess nuclear weapons or to permit the storage or deployment of nuclear weapons on their territories by other countries. NWFZ treaties are currently in force in Latin America, through the Treaty of Tlatelolco (1967); the South Pacific, through the Treaty of Rarotonga (1985); Southeast Asia, through the Treaty of Bangkok (1995); and Africa, through the Treaty of Pelindaba (1996).

Additionally, most nuclear weapons states have made no-first-use declarations or negative security assurances, meaning that they have agreed not to use nuclear weapons against non–nuclear weapons states that have signed the NPT except when invaded or otherwise attacked.

—*Abe Denmark*

See also: Negative Security Assurances; Nuclear Nonproliferation Treaty

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NONPROLIFERATION

The term "nonproliferation" refers to a worldwide effort to prevent the spread of nuclear weapons and their delivery systems as well as to keep nations that do not have nuclear weapons from acquiring them. Another focus of nonproliferation activities is disposing of plutonium and highly enriched uranium from dismantled Russian nuclear weapons, as well as preventing any form of nuclear materials from falling into the hands of terrorists or ending up on the black market. Nonproliferation also involves efforts to compel nuclear weapons states, including the United States, to pursue complete nuclear disarmament under the terms of the 1968 Nuclear Nonproliferation Treaty (NPT). In the aftermath of the terrorist attacks of September 11, 2001, the focus of nonproliferation efforts has shifted from nation states to terrorist groups in the goal of keeping them from acquiring nuclear weapons. There are many U.S. agencies that have programs focusing on nuclear nonproliferation, but the three main departments where nonproliferation activities occur are the Department of State, the Department of Defense, and the Department of Energy.

Nonproliferation Efforts

Since the 1950s, the United States has been a leader in nonproliferation efforts, creating a broad international structure including treaties, inspection mechanisms, and agreements backstopped by a wide range of domestic legislation. The Nuclear Nonproliferation Treaty is the centerpiece of the international structure. Under the NPT, there are five declared nuclear states: the United States, the United Kingdom, Russia, China, and France. These nuclear weapons states have agreed not to assist non–nuclear weapons states to acquire nuclear weapons. Under the NPT, the declared nuclear states have agreed to reduce and eventually eliminate their nuclear stockpiles. The signatory non-weapon states agreed not to develop nuclear weapons and to allow for inspections of their nuclear facilities and materials by the International Atomic Energy Agency to ensure that peaceful nuclear technology will not be used for military purposes. The NPT also guarantees non-weapon states access to peaceful nuclear technology. Participation in the NPT has been almost universal since the end of the Cold War. Within the world community, only Israel, India, and Pakistan have refused to sign the NPT. (Cuba joined in November 2002.) (*See* Non–Nuclear Weapons States; Nuclear Nonproliferation Treaty; Nuclear Weapons States.)

The international community relies on a variety of positive and negative incentives to discourage states from acquiring nuclear weapons. If a nation is facing security threats, the United States might provide security guarantees in the form of "extended deterrence," making it possible for allies to avoid developing nuclear weapons of their own (*see* Extended Deterrence). An additional nonproliferation tool has been technology denial and export controls. Nations that are suppliers of nuclear technology try to prevent the countries that are trying to develop nuclear weapons from buying the necessary equipment, particularly the fissile material, to build a nuclear device. The focus of these technology and material denial efforts has been on Russia and the former Soviet republics. Lost or stolen nuclear material and technology in these regions could easily find its way to a nuclear materials black market. Sanctions are another way to deter and punish proliferators. These sanctions cut off U.S. and international aid, military cooperation, economic assistance, and technology if a nation violates nonproliferation agreements. By maintaining a strong military force, the U.S. Department of Defense tries to deter the acquisition and use of nuclear weapons. Counterproliferation is the military component of a nonproliferation policy, using military force to destroy or preempt the development of weapons of mass destruction.

Nonproliferation experts have identified three major issues facing the international community. The first is a regional focus on a number of potential flash points: the Middle East (specifically Iraq, Iran, and Israel), North Korea, and the India-Pakistan arms race. The second problem is the disposal of plutonium and highly enriched uranium from dismantled Russian nuclear weapons. Another major issue is the international effort to convince nations that have signed the NPT to fulfill their pledge and abandon their nuclear arsenals (*see* Highly Enriched Uranium; Indian Nuclear Weapons Program; Iran's Nuclear Weapons Program; Iraqi Nuclear Forces and Doctrine; Israeli Nuclear Weapons Capabilities and Doctrine; North Korean Nuclear Weapons Program; Pakistani Nuclear Forces; Plutonium; Uranium).

Structure and Organization of the International Nonproliferation Regime

The goal of the international nonproliferation regime is to prevent the spread of nuclear weapons. The regime consists of treaties, international organizations, and agreements. There are four major components of the regime. First is the Nuclear Nonproliferation Treaty, which entered into force in the 1968. Second is the International Atomic Energy Agency (IAEA). The IAEA is an international organization with close ties to the United Nations. It helps to verify NPT compliance and polices a safeguards regime. It also negotiates inspection agreements with NPT members to help demonstrate that the use of nuclear materials is for peaceful uses (*see* International Atomic Energy Agency).

Third, informal international groups play an important part in the international effort to slow the proliferation of nuclear weapons. The Nuclear Suppliers Group, for instance, is a committee of nuclear supplier nations that upholds the multilateral guidelines for nuclear exports. The Zangger Committee is an NPT affiliate that maintains a trigger list of nuclear items requiring safeguards. In 1992, the Nuclear Suppliers Group and Zangger guidelines were strengthened following the end of the Gulf War and the crisis with Iraq's nuclear weapons program. Another component of the nonproliferation structure is the Missile Technology Control Regime (MTCR), which restricts exports of nuclear-capable missiles (*see* Missile Technology Control Regime; Nuclear Suppliers Group; Zangger Committee).

The fourth component of the nonproliferation regime is the Convention on Physical Security for Nuclear Materials, which began in 1987. The convention set the stage for international security standards for using, transporting, and storing nuclear materials.

Current Concerns and Issues

The five permanent members of the UN Security Council are also the five NPT-designated nuclear weapons states. Nevertheless, there are few states that view nuclear weapons as the best way to ensure their security. Two major powers, Germany and Japan, are non-weapons states. In 1991, South Africa dismantled its nuclear program and renounced nuclear weapons. Under civilian rule, Brazil and Argentina abandoned their secret nuclear programs and joined the NPT. Countries of the former Soviet republic, such as Ukraine, Belarus, and Kazakhstan, viewed nuclear weapons as creating more problems then security benefits, returned the Soviet weapons, and joined the NPT.

The interest in gaining nuclear weapons has not disappeared, however. The ultimate goal of nonproliferation advocates—complete nuclear disarmament—is still a distant dream. India and Pakistan continue to test nuclear devices. Iran's pursuit of nuclear technology remains a threat. North Korea may have recently become the world's newest unofficial nuclear state. Overall, the international community needs to continue its nonproliferation efforts to ensure that rogue states and nonstate actors do not acquire radioactive materials or nuclear weapons.

—*Laura Fontaine*

See also: Disarmament; Proliferation

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NORTH AMERICAN AEROSPACE DEFENSE COMMAND (NORAD)

On August 18, 1940, President Franklin D. Roosevelt and Canadian Prime Minister Mackenzie King issued the "Ogdensburg Declaration," a document based on the concept of joint defense of "the northern half of the western hemisphere." During World War II, a Joint Board of Defense created at Ogdensburg made recommendations on mutual defense activities to the two governments. After the war, Canada and the United States issued a joint statement that set forth the main principles that would underlie their continued collaborative relationship, including exchange of selected service personnel, cooperation in defense exercises, testing of defense materials, encouragement of common designs and standards in arms, equipment, and training, and mutual and reciprocal availability of military, naval, and air facilities in each country.

The vulnerability of Canada and the United States to air attack, possibly involving the use of Soviet atomic weapons, led to the creation of a continental early warning system in the years 1951–1955. In the "Pinetree" agreement of August 1951 (officially the "Exchange of Notes [August 1, 1951] between Canada and the United States of America Constituting an Agreement Regarding the Extension and Co-ordination of the Continental Radar Defence System"), the two governments approved the extension of the continental radar defense system. In 1953, they authorized an experimental program known as "Project Counterchange," an initiative that was to grow into the Distant Early Warning Line established under an exchange of notes in May 1955. Three years later, the idea of a hardened command and control center was identified as an important defensive measure against Soviet bombers. After the Soviet launch of Sputnik in 1957, the U.S. government focused more on early warning and the ballistic missile threat.

An integrated North American Air Defense Command (NORAD) became operational on September 12, 1957. The binational command was based in Colorado Springs, Colorado, first at Ent Air Force Base and then, since the early 1980s, at Peterson Air Force Base, with its various warning centers located inside Cheyenne Mountain, also near Colorado Springs (*see* Cheyenne Mountain). Cheyenne Mountain was selected based on three key criteria: It was geographically centered in North America; it was an area of low seismic activity; and there was already an established military presence in Colorado Springs. Excavation and construction for the complex began in June 1961, and the complex was operational on April 20, 1966.

On May 12, 1958, the North American Air Defense agreement between the United States and Canada officially establishing NORAD was formalized. This document included principles governing the organization and operation of NORAD and called for a renewal of the agreement every ten years. It has been reviewed, revised, renewed, or extended several times in the years since NORAD's founding.

The original objectives of NORAD were to assist Canada and the United States in safeguarding the sovereignty of their airspace; to contribute to the deterrence of an attack on North America by providing a capability for aerospace surveillance, threat evaluation, and attack warning and for defense against attack by air or space; and, should deterrence fail, to ensure an appropriate response against attack by providing for the effective use of the two countries' air defenses. In 1975, responsibility for warning and assessment of an aerospace attack was added to the NORAD mission. In 1981, the name of the command was changed to the North American Aerospace Defense Command, reflecting a changed threat to North America in the form of Soviet intercontinental ballistic missiles.

The commander in chief of NORAD (CINCNORAD) is a U.S. general officer, and the deputy commander in chief is a Canadian. Until October 2002, CINCNORAD was "double-hatted" as commander in chief of the U.S. Space Command (CINCSPACE). On October 1, 2002, USSPACECOM disestablished and moved under the U.S. Strategic Command (USSTRATCOM) at Offutt Air Force Base, Nebraska. U.S. Northern Command (USNORTHCOM) was established on October 1, 2003, and CINCNORAD is now dual-hatted as the commander of USNORTHCOM. USNORTHCOM plans, organizes, and executes homeland defense and civil support. Its area of responsibility for this command includes air, land, and sea approaches to the continental United States, Alaska, Canada, Mexico, and surrounding waters out to 500 miles.

—Patricia McFate

See also: Early Warning

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NORTH ATLANTIC TREATY ORGANIZATION (NATO)

The North Atlantic Treaty Organization (NATO) was founded by the North Atlantic Treaty, signed in Washington, D.C., on April 4, 1949. The treaty's original purpose was to help the United States, Canada, and European allies deal with the military and ideological threat posed by the Soviet Union. At the end of the Cold War following the collapse of the Soviet Union, NATO members decided to preserve the alliance to help emerging democracies become integrated into the European community and to deal with new risks and uncertainties, including threats from rogue states and weapons of mass destruction. In the early years of the twenty-first century, the allies decided to allow NATO to take on tasks beyond Europe to deal with more distant threats to the security of the member states.

The North Atlantic Treaty was designed to counter Soviet expansion and military power, but it was based on common values, specified no enemy, protected the sovereign decision-making rights of all members, and was written in sufficiently flexible language to accommodate changing international circumstances.

The first major adjustment made by NATO came early. In the aftermath of the North Korean attack on South Korea, NATO members launched a military buildup in Europe. They also began to construct an integrated command structure in the early 1950s. Neither of these developments had been anticipated when NATO was first formed but were judged necessary after the outbreak of war in Korea. The alliance was adapted again following the 1954 failure of the European Defense Community (EDC), which was intended to coordinate a common European military policy. In the mid-1960s, NATO had to adapt to France's departure from the Integrated Command Structure. In 1967, the allies revamped NATO's strategy by adopting the doctrine of "flexible response" to a possible Warsaw Pact attack (*see* Flexible Response). In the same year, NATO approved the Harmel Report, taking on the mission of promoting détente in addition to the more traditional mission of sustaining deterrence and defense (*see* Détente; Deterrence). In the 1990s, the allies reoriented NATO's goals and activities to take into account the peaceful democratic revolutions in Eastern and Central Europe and the dissolution of the Warsaw Pact and the Soviet Union. NATO became a way to integrate the democracies that emerged out of the former Warsaw Pact into an expanding Euro-Atlantic security structure that helped to prevent the emergence of balance-of-power politics on the continent.

At its founding, the most prominent aspect of NATO was its requirement for individual and collective action for defense against armed attack. Article 5, the North Atlantic Treaty's collective defense provision, provided that "an armed attack against one or more of them in Europe or North America shall be considered an attack against them all."

At the end of the Cold War, the allies began adapting NATO strategy and force deployments to the new circumstances. The changes gave more prominence to Article 4, which stated, "The Parties will consult together whenever, in the opinion of any of them, the territorial integrity, political independence or security of any of the Parties is threatened." The allies also placed additional emphasis on problems posed by the proliferation and potential use of nuclear, biological, and chemical weapons of mass destruction. At the NATO summit meeting in

Headquarters of the North Atlantic Treaty Organization on the outskirts of Brussels, Belgium. (NATO Photos)

Washington in 1999, the allies established a NATO Weapons of Mass Destruction Center designed to improve intelligence and information-sharing about proliferation, to assist allies in enhancing the military capabilities to work in a nuclear, chemical, or biological environment, and to support nonproliferation efforts.

Meeting in Prague, Czech Republic, in November 2002, the NATO allies agreed to establish a NATO Response Force that could respond to security challenges in or beyond Europe. This marked acceptance by all the allies that NATO's security responsibilities are not limited by geography. In the 1990s, the allies had already taken the first step in expanding NATO's roles and missions by undertaking important peace enforcement and peacekeeping missions in the Balkans. NATO took a further step beyond Europe in 2003 when the allies agreed to take responsibility for the International Security Assistance Force in Afghanistan and play a role in post–Gulf War Iraq.

NATO also has adapted by enlarging its membership. The Czech Republic, Hungary, and Poland joined NATO in the 1990s. At the November 2002 Prague summit, the allies invited seven additional countries (Bulgaria, Estonia, Latvia, Lithuania, Romania, Slovakia, and Slovenia) to join, bringing membership to a total of twenty-six Euro-Atlantic nations. NATO has also established special cooperative relationships with both Russia and Ukraine.

In recent years, NATO and the European Union have worked out ways of ensuring that defense cooperation in the EU remains consistent with NATO cooperation.

The North Atlantic Council is NATO's main decision-making body. The "permanent representatives" of the member states meet regularly at its headquarters in Brussels, Belgium; foreign ministers meet twice a year; and member heads of state and government attend occasional summits. NATO's defense policy decision-making organization, the Defense Planning Committee, is composed of NATO ministers of defense or their representatives (excluding France, which left the NATO Integrated Command Structure in 1967). Nuclear matters, including policy, force structure, and basing locations, are decided in the Nuclear Planning Group (NPG). All members are invited to participate, although only seven NATO states have nuclear missions. (The United States, Great Britain, and France are the only member states possessing their own nuclear weapons; the other four use U.S. nuclear warheads under "dual key" arrangements whereby the United States retains release authority even when the weapon is deployed on another nation's delivery system.) Beginning in the 1970s, the NPG was supported by a new committee, the High Level Group, which conducted outside studies and analyses for the Nuclear Planning Group.

The Military Committee includes the chiefs of staff of NATO militaries. The Integrated Command Structure, following substantial reform and consolidation in the 1990s, includes the Supreme Allied Command Europe, headed traditionally by an American four-star general (the supreme allied commander Europe, or SACEUR), with a European deputy commander. The new NATO Transformation Command is led by a U.S. flag officer with a European deputy. NATO's civilian organization is run by an International Staff headed by a secretary general from one of the European member states, NATO's top civilian official.

NATO continues to serve as an important bridge between the United States and Europe. This "indispensable link" allows the allies to coordinate their security policies, including responses to challenges posed by terrorism and weapons of mass destruction. The absence of a unifying threat such as that posed by the Soviet Union during the Cold War, the emergence of new challenges well beyond NATO's borders, and differences between the United States and some allies over how best to deal with those threats have fed speculation that NATO is dead or dying. NATO's demise, however, has been predicted by observers since its inception, and the alliance has withstood several severe tests in the past. Whether it will continue in the future will depend on the extent to which the United States and the allies adapt the alliance to meet changing security demands and use it as a means for promoting U.S.-European security cooperation and for dealing with future threats to their security.

—Stanley R. Sloan

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NORTH KOREAN NUCLEAR WEAPONS PROGRAM

Suspicions of ongoing weapons of mass destruction programs in the Democratic People's Republic of Korea (DPRK, or North Korea) have been a focal point of international security concerns since the 1990s. The Korean peninsula remains a volatile region decades after the Korean War, which ended in a ceasefire in 1953. Movement toward unification of North and South Korea has been very slow and fraught with tension. The parties to the conflict never signed a peace agreement and remain technically at war. As a result, one of the DPRK's longstanding aspirations has been to sign a peace treaty with the United States, distinct from any peace treaty involving the Republic of Korea (ROK, or South Korea), a goal consistently rejected by South Korea and the United States. This history has exacerbated the security threat posed by weapons of mass destruction in North Korea.

The genesis of a North Korean nuclear arms program likely dates back to Premier Kim Il Sung's decision to obtain a nuclear capability following the Korean War, and to North Korea's acquisition in 1965 of its first nuclear research reactor. The North Korean nuclear program has focused on the acquisition of fissionable material. The country possesses vast natural uranium deposits, which have been developed and mined since the mid-1970s.

In the early 1980s, it became known that North Korea was constructing a small graphite reactor at Yongbyon. This revelation led the international community to pressure North Korea to accede to the Nuclear Nonproliferation Treaty (NPT) of 1968. The North Koreans signed the NPT in 1985. North Korea's Yongbyon nuclear reactor came online in 1986. It was reported to have startup problems but could have produced 4 to 7 kilograms of plutonium—roughly enough for one nuclear weapon—per year. The production of plutonium at Yongbyon is the basis of frequent public assertions that Pyongyang may possess one to three nuclear weapons (*see* Nuclear Nonproliferation Treaty).

Although it joined the NPT in 1985, North Korea asserted that it would not sign a nuclear safeguards agreement with the International

Workers pour concrete at a construction site to build nuclear reactors in the North Korean village of Kumho, August 2002, under the auspices of the Korean Peninsula Energy Development Organization. (Lee Jae-won N/Reuters/Corbis)

Atomic Energy Agency (IAEA), a requirement of its NPT membership, until the United States removed its tactical nuclear weapons from South Korea. President George H. W. Bush agreed to do this in 1991, and in 1992 North Korea signed the safeguards agreement. Many believed that the threat posed by the Yongbyon reactor had been contained. In 1991, North Korea also signed the North-South Joint Declaration on Denuclearization of the Korean Peninsula, under which the signatories agreed not to develop, receive, test, or use nuclear weapons (*see* International Atomic Energy Agency; Joint Declaration on Denuclearization of the Korean Peninsula).

In May 1992, the IAEA began inspections to verify the initial declaration of nuclear materials provided by the DPRK. The North Koreans asserted that they had separated approximately 100 grams of plutonium when they removed a few damaged fuel rods from their reactor in 1990. IAEA inspections revealed discrepancies in this report and indicated that plutonium had been separated in 1989, 1990, and 1991. North Korea denied separating plutonium on these occasions.

Adding to suspicions aroused by this discrepancy were intelligence reports that indicated the existence of two hidden nuclear waste sites at Yongbyon. Requests by the IAEA to perform special inspections on these sites were rejected, and in February 1992, the IAEA announced that it could not verify North Korea's declaration of its plutonium inventory.

It was in response to ultimatums presented to North Korea requiring it to submit to special inspections of the two hidden nuclear waste sites that the DPRK announced, on March 12, 1993, its intention to withdraw from the NPT. The DPRK ultimately agreed to postpone this withdrawal following assurances provided by the United States. In these assurances, the United States said it would refrain from the use or threat of use of force, pledged nonintervention in North Korean affairs, and promised to hold bilateral talks with North Korea. Negotiations between the United States, North Korea, and the IAEA, however, yielded little progress on resolving North Korean noncompliance with its NPT obligations.

In April 1994, North Korea announced its intention to unload a small nuclear core from a reactor. It proceeded to do so at a pace that undermined the IAEA's ability to ascertain if it had diverted spent fuel in the past. In addition, the IAEA was unable to test any of the fuel rods that were moved during the unloading process. In addition to its reactors, North Korea had begun to build a plutonium separation plant to handle reprocessing of reactor fuel. It is believed that Russia and China provided North Korea with the basic knowledge necessary to reprocess plutonium, although investigations have indicated that North Korea did not receive significant foreign assistance for its nuclear program.

IAEA director Hans Blix expressed his reservations about the North Korean nuclear program to the UN Security Council in June 1994. This news was met with calls for decisive action against the DPRK and increased the pressure on the United Nations to impose sanctions. North Korea indicated that it would consider the imposition of sanctions an act of war. A crisis was temporarily averted by a diplomatic visit to North Korea by former U.S. President Jimmy Carter, who offered high-level bilateral talks in exchange for a freeze on North Korea's nuclear program, including a pledge not to reload a small reactor with fresh fuel or to reprocess discharged fuel. North Korea also agreed to allow two IAEA inspectors to remain at the reactor site to monitor activities there.

After a brief period of uncertainty following the death of North Korean leader Kim Il Sung, the promised high-level talks took place. They resulted in an "Agreed Statement" in August 1994, which laid the foundation for the "Agreed Framework" reached on October 16 of the same year. The stated objective of the agreement was to reach an overall resolution of the nuclear issue on the Korean peninsula.

The implementation of the Agreed Framework was to occur gradually. North Korea froze activity at its 5-megawatt experimental reactors and reprocessing facilities. This freeze was monitored by the IAEA, which also resumed its routine and ad hoc inspections of facilities not subject to the freeze. North Korea agreed not to build any other reactors or reprocessing facilities and to remain party to the NPT.

Integral to the Agreed Framework was the signatories' promise to provide North Korea with two light-water reactors in exchange for its concessions to restrict its nuclear ambitions and to dismantle its graphite-moderated reactors (*see* Gas-Graphite Reactors; Light-Water Reactors). An international consortium, the Korean Energy Development Organization (KEDO), was to fund and undertake construction. The United States also agreed to make up North Korea's energy deficiency in the interim period by supplying it with 500,000 tons of heavy fuel oil annually. U.S. officials provided formal assurances against the threat or use of nuclear weapons against North Korea.

Concerns about a possible North Korean nuclear program were reignited by intelligence reports in 1998 of an underground nuclear facility at Kumchang-ni. North Korea eventually agreed to accept an inspection of Kumchang-ni in 1999 in exchange for food assistance, and no evidence of nuclear activities was found at the site at that time or in follow-up visits in 2000.

Progress was made in U.S.–North Korea relations in the final months of President Bill Clinton's administration. A joint communiqué issued in 2000 stated that the parties had "no hostile intention" toward each other. This trend reversed during the George W. Bush administration, and bilateral relations deteriorated rapidly following President Bush's description of North Korea as a member of an "axis of evil" and the reported consideration of the use of nuclear weapons against North Korea in the 2002 U.S. Nuclear Posture Review. In March 2002, the United States decided not to certify North Korea as compliant with the Agreed Framework for the first time since 1994, and the DPRK threatened to walk away from the deal in response to U.S. pressure.

Implementation of the agreement was delayed by various factors, and initial projections of completing the first light-water reactor by 2003 were pushed forward as far as 2008. These delays, in addition to the perceived failure of the United States to implement fully the security assurances provided in the Agreed Framework, purportedly led to the decision of North Korea to revitalize its nuclear weapons program. Others believed that the North Korean decision to abandon the Agreed Framework was motivated by nuclear extortion, an effort to extract additional economic and political concessions in exchange for a commitment to abandon its nuclear ambitions.

On October 16, 2002, North Korea admitted to U.S. delegates that despite its obligations under the NPT and the 1994 Agreed Framework, it had an ongoing nuclear weapons program based on uranium enrichment. It stated its belief that this admission nullified the 1994 Agreed Framework. This situation constituted a major violation of the NPT and called the future of the Korean Energy Development Organization, created to implement the Agreed Framework, into question, precipitating yet another crisis situation on the Korean peninsula.

After North Korea's admission, the United States, Japan, and South Korea halted oil deliveries. In response, North Korea expelled IAEA inspectors and removed surveillance cameras at its nuclear facilities. It then announced its withdrawal from the NPT and demanded direct negotiations with the United States, to which the United States agreed in February 2003 despite previous assertions that North Korea's abandonment of its nuclear program was a prerequisite to discussions.

North Korea has undertaken four and possibly five missile development and production programs. These programs have produced missiles that were reverse engineered, such as the Scud-B, improvements of existing designs, such as the Scud-C, and weapons primarily of North Korean origin, such as the Nodong. North Korea began its first missile reverse-engineering program utilizing a small number of samples, possibly from Egypt. Since then, it has received modest foreign assistance with its missile programs, which has produced missiles of ever-increasing range and reliability. Extensive exports of its missiles and missile technology have provided a much-needed influx of hard currency for the North Korean regime.

North Korea's missile exports have been a major source of tension in its relations with the United States. In 1996, the United States and North Korea met for their first round of bilateral missile talks. Relations were strained in 1999 by North Korea's test of the multistage Taepo Dong-1 missile over Japan. The missile traveled more than 850 miles, landing between northern Japan and Russia. Bilateral missile talks yielded little substantial results until September 1999, when North Korea agreed to a moratorium on testing any long-range missiles for the duration of talks with the United States. North Korea continued to adhere to this self-imposed testing moratorium, and periodic negotiations aimed at resolving the issue of North Korea's missile programs and exports continued up until its revelation of a secret nuclear program in 2002.

—Jacqueline Simon

See also: International Atomic Energy Agency; Joint Declaration on Denuclearization of the Korean Peninsula; Missile Defense; Payload; Rumsfeld Commission; South Korean Nuclear Weapons Program; Strategic Forces

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NSC 20/4; NSC 30; NSC 68; NSC 162/2; NSDD 13; NSDM 242

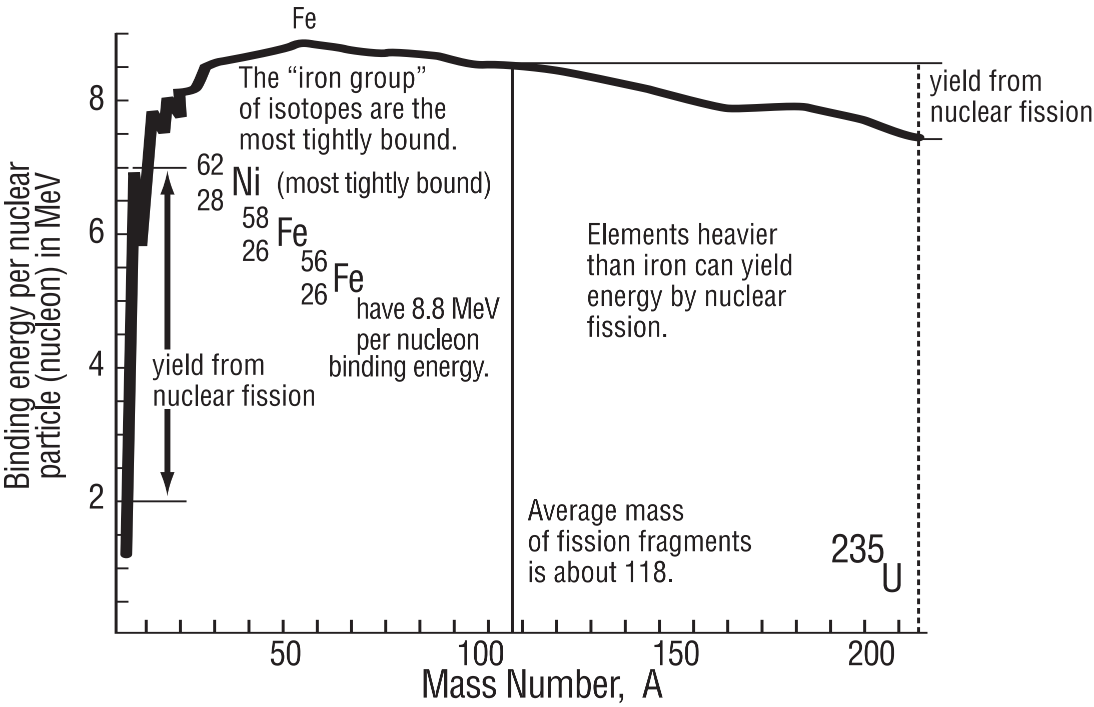
See United States Nuclear Forces and Doctrine

NUCLEAR BINDING ENERGY

Nuclear binding energy is the amount of energy necessary to separate protons or neutrons from a nucleus during the fission process. It is also the energy released when separate protons and neutrons are combined to form a single nucleus in the fusion process. In essence, it can be thought of as the energy that holds the nucleus together. Binding energy is important to nuclear power and weapons because it is the energy that is released in nuclear processes.

Nuclear binding energy comes from the strong nuclear force, that is, the force that holds the nucleus together. The strong nuclear force, which is sometimes called the "strong interaction," is a fundamental force in nature. The nucleus is made up of positively charged protons, and neutrons, which have no charge association. Even though the strong nuclear force is not completely understood, the force must be strong enough to overcome the repelling force of positively charged protons.

Figure N-1: Binding Energy per Nucleon



Protons and neutrons are sometimes called "nucleons." A nucleus always has less mass than the sum of its constituent nucleons. This difference in mass is called the "mass defect" of the nucleus. Since mass can be equated to energy by Einstein's equation, it follows that the mass deficit also can be expressed in terms of energy.

The binding energy of an atom can be calculated using Einstein's equation: $E = \Delta mc^2$, where E is rest energy, Δm is the difference between the mass of constituent nucleons and the mass of the nucleus, and c is the speed of light.

Binding energy may be conveniently represented as the amount of energy per nucleon. Figure N-1 shows the binding energy per nucleon by atomic mass number. It illustrates which elements release energy by the fusion and fission processes. This curve also shows that, in general, lighter elements have a relatively smaller amount of binding energy (that is, fewer nucleons with less binding energy per nucleon) and heavier elements have a higher amount of binding energy.

—Don Gillich

See also: Fission Weapons; Fusion; Neutrons

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NUCLEAR EMERGENCY SEARCH TEAMS (NESTS)

Nuclear Emergency Search Teams (NESTs) are national response teams that react to nuclear threat incidents. NEST capabilities include searching for, identifying, and disarming stolen or manufactured nuclear weapons, nuclear materials, or radiological dispersal devices. These teams are staffed with nuclear weapons experts from the national labs and the Department of Energy (DOE).

In 1974, the Federal Bureau of Investigation (FBI) received a threat that unless a large sum of cash was delivered, a nuclear device would be detonated in Boston, Massachusetts. Even though the threat was later determined to be a hoax, the federal government viewed it as a threat that could materialize for real in the future. In response to this new threat assessment, Nuclear Emergency Search Teams were established by the end of 1975 to assist the FBI in responding to nuclear and radiological incidents.

The Department of Energy's Nevada Operations Office determines which assets will be sent in response to a given situation. NESTs are usually tailored to a particular situation or threat, and operations officers can draw on a pool of more than 600 individuals who are experts in nuclear weapons design, radiation, and other nuclear weapons effects. NEST personnel include experts in more than twenty disciplines, including chemistry, physics, mathematics, and communications.

The teams also have specialized equipment, including helicopters, airplanes, and a fleet of vehicles specially modified with advanced radiological sensing devices. Other specialized equipment includes hand-held and remote radiation detection systems. Because NESTs are usually secretly deployed, most of the equipment at their disposal is concealed from public attention by using briefcases or backpacks for the smaller detection devices, and vans and trucks that appear to be commercial vehicles for the larger sensors.

There are two branches of NEST: the Accident Response Group, which responds to accidents and incidents pertaining to U.S. nuclear weapons, and the Joint Technical Operations Team, which responds to the threat of nuclear and radiological weapons by terrorist organizations.

Since the events of September 11, 2001, greater emphasis is being placed on NEST training and readiness to respond to events involving nuclear or radiological materials and weapons. NESTs are now periodically deployed to conduct searches in major U.S. cities. The Department of Homeland Security and the Department of Energy are establishing new command and control relationships for NEST.

—*Don Gillich*

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NUCLEAR FREEZE MOVEMENT

See Antinuclear Movement

NUCLEAR FUEL CYCLE

The nuclear fuel cycle describes the transformation of uranium (U) from its raw material into either enriched uranium or plutonium (Pu) fuel for use in nuclear energy production or in a nuclear weapon. The cycle is dual-use in nature, and materials can be diverted for use in nuclear weapons development at any stage of the cycle.

Uranium is a naturally occurring element, but plutonium must be created through a nuclear reaction. Uranium can either be enriched to concentrate its fissionable isotopes into enriched uranium, or it can be transformed into plutonium in a reactor. Both materials are usable in power-generating nuclear reactors as well as in the manufacture of nuclear weapons.

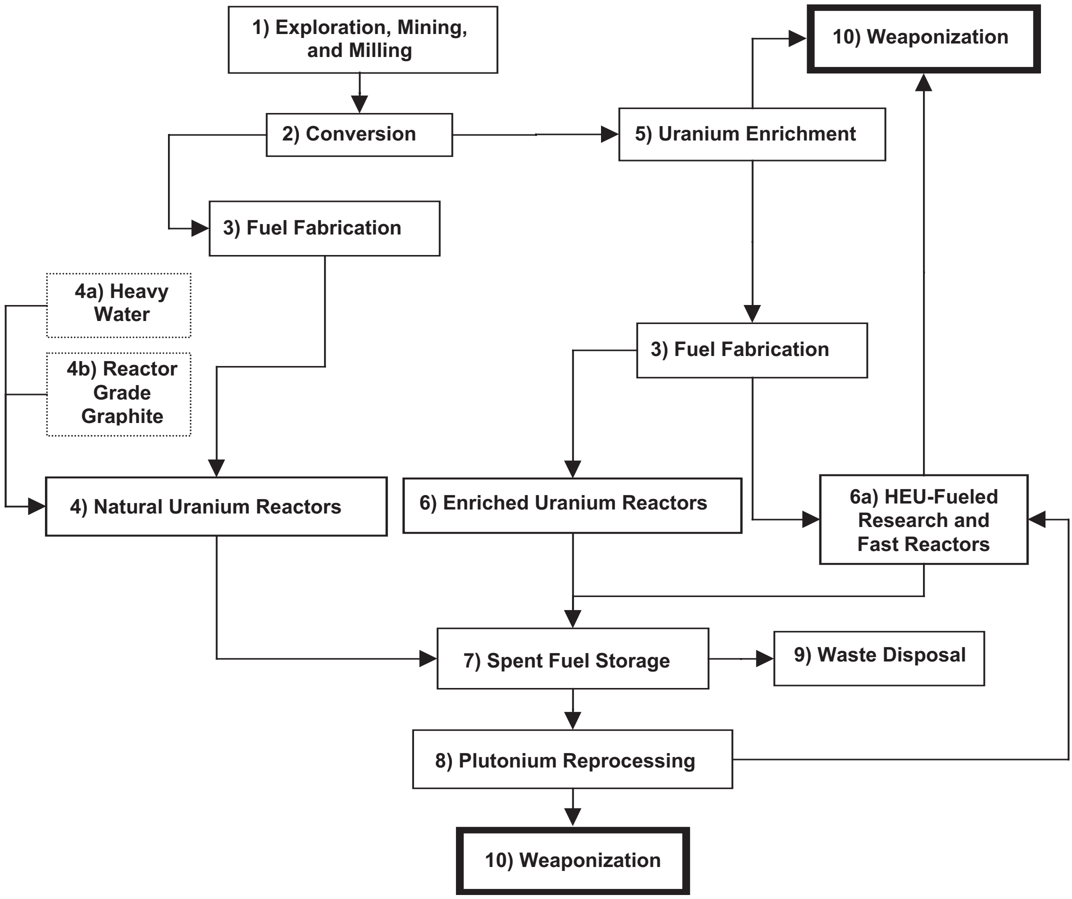
Depending on the type of fuel and the purpose of the reactor, there are two main routes uranium can thus follow through the nuclear fuel cycle: natural uranium reactors and enriched uranium reactors. Both routes have consequences for nuclear weapons proliferation.

The Cycle

The nuclear fuel cycle is a complex process. The first stage of the fuel cycle involves the geological exploration of uranium reserves followed by the mining of the raw material, uranium ore. Because percentages of uranium in ore are very low, large amounts must be mined to obtain material for use in a reactor. Mining can be accomplished in two ways: in situ leaching, and traditional mining. Traditional mining involves blasting and digging the uranium ore rock from the earth. The ore is separated from the rock, then purified and refined into a powdery yellow substance called "yellowcake." Yellowcake is also referred to as "natural uranium." In situ leaching involves the pumping of a leaching liquid such as ammonium-carbonate or sulfuric acid into the ground and extracting the fluid. A processing plant separates the leaching liquid from the uranium. The extracted uranium is then purified and refined into yellowcake.

Before being usable in a reactor, yellowcake must be further refined, converted, and fabricated into fuel. It is converted through a multistep chemical process into uranium metal or into the gas uranium hexafluoride (UF_6) to be used as feedstock for enrichment. Fuel fabrication produces fuel assemblies that are composed of tubes of fuel pellets called fuel

Figure N-2: The Nuclear Fuel Cycle



rods. In a nuclear reactor, the fuel rods are bombarded with neutrons to cause a nuclear reaction that releases energy that can be converted into electricity. A certain percentage of the rods are also transformed into materials usable in the nuclear weapons production process.

Natural uranium–fueled reactors, such as heavy-water reactors, graphite-moderated reactors, and some research reactors, use uranium that has not had its isotope level enriched. Moderators are used to slow the bombardment of neutrons at the fuel long enough to allow the nucleus of the uranium 235 (U-235) to split. These reactors are particularly dangerous in terms of weapons proliferation. These types of reactors produce material that does not require an enrichment capability to produce plutonium, a by-product of the nuclear reaction and a fuel for nuclear weapons. As part of the energy production process, the fuel rods in these natural uranium–fueled reactors are irradiated, and as the uranium absorbs neutrons, it becomes plutonium. This plutonium requires reprocessing before it can be used as fuel for a nuclear weapon (*see* Fuel Fabrication; Gas-Graphite Reactors; Heavy Water; Isotopes; Neutrons; Plutonium; Reactor Operations; Research Reactors; Uranium).

Natural Uranium Reactors

Several types of reactors are used to produce electricity. Heavy water (deuterium oxide), a moderator, allows for the fission of natural uranium, making uranium enrichment unnecessary, and thus bypassing a difficult step of the fuel process. This feature makes heavy-water production highly desirable to nations seeking an indigenous nuclear infrastructure. Tritium, used as a neutron source to boost the explosive power of a nuclear weapon, can be produced from heavy water. Some reactors use graphite as a moderator. Reactor-grade graphite also allows for the fission of natural uranium, making uranium enrichment unnecessary and thus also bypassing a difficult step of the fuel process.

Uranium Enrichment

The enrichment of uranium involves the separation of the uranium into U-238 and U-235 atoms. U-235 atoms are fissionable. By concentrating U-235 atoms it is possible to produce a nuclear reaction. Uranium can be enriched to different concentrations. An enrichment level less than 20 percent U-235 is considered low enriched uranium (LEU); greater than 20 percent U-235 is considered highly enriched uranium (HEU), and weapons-grade uranium is enriched to greater than 90 percent. To produce 25 kilograms of weapons-grade uranium, it would require approximately 5,000 kg of natural uranium.

There are several methods of uranium enrichment. For determined proliferators with the ability for high technical precision, the gas-centrifuge method is likely to have appeal, as it can produce large amounts of weapons-grade uranium quickly. In this method, uranium hexafluoride is spun in cylinders so that centrifugal force moves the heavier U-238 atoms to the outer edges of the cylinder. The concentrations of U-238 are then removed, and repeated iterations continue to increase the ratio of U-235 atoms to U-238 atoms until the desired concentration of U-235 is reached. A nation seeking weapons-grade uranium could acquire enough for several nuclear weapons per year with a large facility of centrifuges.

Gaseous diffusion is the most common enrichment method and is attractive to nations seeking an indigenous nuclear weapons capability because it can produce substantial quantities of weapons-grade uranium relatively quickly. It requires large amounts of electricity, however, which makes it difficult to undertake clandestinely. At one time, gaseous diffusion cascades in the United States consumed 4 percent of the electricity produced in the country.

Gaseous diffusion involves the transfer of uranium hexafluoride through a series of membranes. The membranes create a separation between a high- and low-pressure environment. The change in pressure causes the atoms to move from the high-pressure side through the membrane to the low-pressure side. The lighter U-235 atoms are collected as they move through the membranes faster than the U-238 atoms. As in the gas-centrifuge method, in gaseous diffusion multiple iterations are required to reach higher and higher concentrations of U-235 atoms. Approximately 4,000 iterations are required to enrich uranium to weapons grade.

Laser separation remains an experimental enrichment method. This method has great appeal because it is extremely efficient. Unlike gas centrifuge and gaseous diffusion, which require many reiterations, laser separation is efficient enough to separate all U-235 atoms in one pass. When perfected, it would provide a means of exploiting nuclear waste for usable uranium.

Another form of enrichment uses laser light to ionize the vapor of U-235 but not U-238. The desired U-235 atoms can then be collected by attracting them with a negatively charged plate. Examples of this method include the atomic vapor laser isotope separation (AVLIS) and molecular laser isotope separation (MLIS) processes.

Aerodynamic separation also uses an enormous amount of energy. In this enrichment method, a gas that includes some uranium hexafluoride is projected across an aerodynamically curved surface into a swirling chamber (much like a centrifuge). As the gas passes over the curved surface, the lighter U-235 atoms separate from the heavier U-238 atoms. It requires hundreds of iterations to reach a desired concentration level in this method. The Becker Nozzle Process, for example, is inefficient and an unlikely choice for nations seeking an indigenous enrichment capability (*see* Enrichment; Highly Enriched Uranium; Low Enriched Uranium).

Enriched Uranium Reactors

Light-water reactors (LWR) fueled with LEU are less of a proliferation threat than heavy-water reactors (HWR) fueled with natural uranium. The spent fuel rods from light-water reactors contain plutonium that requires reprocessing to be usable in a nuclear weapon. By contrast, the spent fuel rods from HEU-fueled research and fast reactors contain weapons-grade plutonium, which makes them highly desirable to nations seeking nuclear weapons. Breeder reactors are designed to produce more fuel than then they are fed. U-235 and Pu-239 release neutrons, which creates a chain reaction and transforms the U-238 into plutonium. The plutonium fissions and helps to keep the reactor critical; alternatively, it can be used in another reactor or reprocessed for a nuclear weapon.

Spent Fuel Storage, Use, and Waste

It is necessary to store fuel leaving a reactor in pools of water to reduce its radioactivity and heat before it is reprocessed for plutonium retrieval. It also has to cool before being sent to a permanent waste disposal facility. Despite the presence of plutonium in spent fuel, the risk of diversion of material at this stage is very low because of the dangers of handling it.

After fuel rods are kept for several months in storage ponds, they can be reprocessed to extract the plutonium from the uranium. The plutonium is then ready to be converted for use as reactor fuel or as fissile material in a nuclear weapon.

In contrast, uranium requires enrichment in order to be used as fissile material. Although the extraction method is fundamentally a chemical one—involving chopping the material, stripping the cladding, and using chemical solvents such as nitric acid to extract radioactive isotopes, facilities must be very carefully constructed to handle nuclear materials. Reprocessing is done with remote manipulators behind heavy shielding (called "hot cells") for safety reasons.

Waste from the nuclear fuel cycle is considered high-level waste and must be stored in a way that protects the environment against radioactivity and toxicity of the substances for an extremely long time. Advanced waste storage includes sealing waste in an insoluble, glass-like material and deep-mine disposal.

Weapons-grade uranium or plutonium must be fabricated into a fissile core for a nuclear weapon, which involves casting and high-precision milling of the metal. The fissile core must be paired with a device capable of causing a fissile reaction in the core. The development of the nonnuclear portion of the weapon is an extremely complex process requiring high-precision arming, fuzing, firing, and safing.

—*Jennifer Hunt Morstein*

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NUCLEAR NONPROLIFERATION TREATY (NPT)

The Nuclear Nonproliferation Treaty (NPT) came into force on March 5, 1970, after being opened for signature on July 1, 1968. The treaty was the result of several years of negotiations involving nuclear weapons states (NWS) and non–nuclear weapons states (NNWS). It has several major objectives: to prevent the spread of nuclear weapons, weapons materials, and technology to additional countries; to promote cooperation among nations in the peaceful uses of nuclear energy; and to achieve global nuclear disarmament.

The NPT is the pivotal component of the nuclear nonproliferation regime, which comprises a set of norms, principles, treaties, and procedures through which countries pledge not to obtain nuclear weapons or help other states acquire a nuclear arsenal. International and bilateral safeguards verify national commitments and thereby prevent defection and cheating. The International Atomic Energy Agency (IAEA), which administers the NPT's safeguards system, is the chief institutional component of the regime. The main principle of the regime is that the spread of nuclear arms is a threat to international security, and its underlying norm is that nonnuclear members of the regime should not develop nuclear weapons and no member should help another nation to build such weapons (*see* International Atomic Energy Agency; Nonproliferation; Safeguards; Zangger Committee).

The NPT is governed by two principles: that the spread of nuclear weapons undermines international peace and security, and that the peaceful application of nuclear energy should be made available to all parties of the treaty. The treaty contains eleven articles. Article I calls upon all NWS parties to the treaty not to transfer nuclear weapons or nuclear explosive devices directly or indirectly, or encourage NNWS to manufacture such devices. Article II stipulates that NNWS will not undertake weapons programs or receive transfers of nuclear weapons or assistance in their manufacture. Under Article III, each NNWS party to the treaty undertakes to accept IAEA safeguards, as negotiated with the IAEA, on their nuclear facilities. It also requires NNWS not to provide fissionable materials to other states without safeguards. Article IV reassures all NNWS of their inalienable right to peaceful nuclear energy research and development, and Article V offers the potential benefits of peaceful nuclear explosions, made available through appropriate international procedures. Article VI requires NWS to pursue negotiations in good faith on effective measures relating to the cessation of the nuclear arms race at an early date and the conclusion of a treaty on general and complete disarmament under strict and effective international control. Article VII states that nothing in the treaty shall prevent any group of states from concluding regional treaties. Article VIII discusses the amending procedure, and Article IX identifies the signature and ratification procedures. Article X guarantees the sovereign right of each party to withdraw from the treaty if it decides that extraordinary events have jeopardized its supreme national interests. Article XI discusses the depository procedures.

Article VI was crucial for many NNWS to agree to sign the treaty. This article remains the only binding commitment to nuclear disarmament in a multilateral treaty on the part of the NWS. The treaty defines a NWS as one that had manufactured and exploded a nuclear weapon or other nuclear explosive device prior to January 1, 1967. All other states are considered NNWS. Under this criterion, only the United States, the Soviet Union (Russia), the United Kingdom, China, and France are legally allowed to keep nuclear weapons. To a great extent, this cap on the so-called "nuclear club" makes the treaty unamendable because there is no room for a future nuclear weapons state to emerge with international legitimacy. Unless the treaty is modified, India and Pakistan, which detonated nuclear weapons in 1998, will remain outside the treaty.

History and Background

Nuclear proliferation has been a concern of the international community ever since the first atomic weapon was used on Hiroshima on August 6, 1945. The United States took the initiative to prevent the spread of nuclear weapons—largely for reasons of preserving its nuclear monopoly—through the Baruch Plan and the Atoms for Peace proposal in the 1950s (*see* Atoms for Peace; Baruch Plan). The Soviet Union opposed these proposals, but by the 1960s Moscow came to the realization that atomic weapons should not spread to other states, especially Germany and Japan. In 1961, an Irish resolution titled the "Prevention of the Wider Dissemination of Nuclear Weapons" was unanimously adopted by the UN General Assembly. In 1965, the General Assembly adopted resolution 2028 setting out five principles on which the nonproliferation treaty was to be based. In early 1968, the Eighteen-Nation Committee on Disarmament submitted a draft treaty to the UN General Assembly, which the assembly subsequently adopted as Resolution 2373 (XXII), by which it approved the NPT.

The NPT was one of the few instances of U.S.-Soviet security cooperation during the Cold War era that also received the support of other key states. The treaty emerged from a U.S.-Soviet consensus that the spread of nuclear weapons to additional states was not in the interest of international security, especially in the management of the superpower competition. The United Kingdom strongly supported this initiative. France and China initially opposed the treaty on political grounds but changed their positions in the early 1990s. France joined the treaty in 1991 and China in 1992, although the latter has continued its supply of nuclear materials to Pakistan, thereby violating its commitment under Article I of the treaty. Despite the superpower initiative, in the end, the treaty came into being as a result of a grand bargain between the NWS and NNWS. Under this bargain, a large number of the NNWS agreed to forgo their nuclear weapons options on two conditions: that the nuclear states commit themselves to supplying technology and materials necessary for civilian applications, and that they pursue nuclear disarmament in good faith.

The superpowers anticipated that the NPT would help put a lid on the nuclear aspirations of potential nuclear states while not upsetting their nuclear arms buildup. Middle powers with major power aspirations (most prominently India and Brazil) and others wishing to maintain a high level of foreign policy autonomy (such as Argentina, Israel, and South Africa) opposed the treaty and initially refused to sign it. These states were not under the security umbrella of a major power and felt that they needed to keep their military options open. The French and Chinese criticism of the treaty was mostly based on symbolic political opposition to superpower politics rather than a frontal assault on the treaty. The two major economic powers, Germany and Japan, were under the security umbrella of the United States and had been pursuing low-profile foreign policies. Despite initial hesitation, these states joined the treaty and ratified it in a few years. Thus a key systemic condition, that is, the dearth of dissatisfied major power challengers, was a necessary condition for the treaty to come into existence. Second-tier nuclear states—China, the United Kingdom, and France—were treated equally and their nuclear weapons status bestowed with legitimacy.

At the time the treaty entered into force, no new state, except the five major powers, had acquired the necessary capabilities for building a nuclear weapons force. Reluctant smaller states were offered side-payments to obtain their adherence to the nonproliferation regime. Many minor powers joined the regime willingly because the NPT was better than nothing at all. With the end of the Cold War in 1991, remaining opposition to the treaty waned. Several previous opponents to the treaty signed the NPT, including Argentina (1995), Brazil (1996), and South Africa (1991, after dismantling the seven nuclear devices it had built). The three successor states of the Soviet Union that had inherited Soviet nuclear weapons based on their soil, Ukraine, Kazakhstan, and Belarus, also joined the treaty in the mid-1990s.

Technical Details

The treaty was initially intended to be in force for a twenty-five-year period. In 1995, however, the members agreed to extend it in perpetuity. Since 1975, the parties have held review conferences every five years. In addition, PrepCom (Preparatory Committee) meetings are held periodically to review the global efforts at nuclear nonproliferation. The IAEA is the chief organization verifying NPT compliance by member states. It conducts periodic safeguard inspections of the member states' nuclear facilities to make sure no violation takes place (that is, it verifies that nuclear materials or technology are not being diverted to military purposes). It also acts as the organization responsible for helping to transfer nuclear materials and technology for peaceful purposes. These IAEA safeguards are technical means of verifying a state's fulfillment of its commitments to the peaceful uses of nuclear energy. In the event of violation by the signatory, the IAEA will refer the matter to the UN Security Council, which has the ultimate authority to determine what sanctions are to be authorized to force compliance (*see* Verification).

Current Status

As of February 2003, there were 188 members to the treaty. With the Cuban government's announcement on September 14, 2002, of its decision to join the treaty, the NPT has become nearly universal. The only states outside the treaty are India, Israel, and Pakistan. North Korea officially withdrew from the treaty in March 2003. This was the first withdrawal by a signatory state, thereby effectively reducing membership to 187. Two NPT signatories—Iraq and Iran—have reportedly been pursuing nuclear acquisition even though they have committed not to do so under the treaty. The forceful regime change in Iraq by the U.S. military intervention in March 2003 would suggest that the future government in Baghdad will adhere to the treaty (*see* Indian Nuclear Weapons Program; Iranian Nuclear Weapons Program; Iraqi Nuclear Forces and Doctrine; Israeli Nuclear Weapons Capabilities and Doctrine; North Korean Nuclear Weapons Program; Pakistani Nuclear Forces).

In April 1995, delegates from 174 of the 178 member states existing at that time met at the UN in New York to discuss the extension of the treaty. Most states parties did not want to bury the treaty, but the deliberations showed the bargaining positions of different states. They were presented with three main options: a proposal by Mexico to extend the treaty in perpetuity with the condition of time-bound progress in nuclear disarmament; rolling extensions of twenty-five years each tied to specific progress in nuclear disarmament, introduced by Indonesia on behalf of six nonaligned movement states; and a proposal for indefinite extension, introduced by Canada, on behalf of the Western countries. More than 100 countries, including the major powers, their allies, and several smaller states, favored the Canadian draft, and 14 nonaligned states opted for the Indonesian option. After a month of negotiations, which initially were deadlocked, the delegates from 174 countries adopted a motion without a vote to extend the treaty in perpetuity. This extension document included "declarations on principles and objectives for nuclear nonproliferation and disarmament" and a resolution on a strengthened review process that met with the support of a majority of states. The review process would include conferences at five-year intervals and preparatory committee meetings three years prior to the conferences to consider ways to promote full implementation of the treaty. In addition, the member states adopted a resolution calling on all countries in the Middle East to accede to the treaty, place their nuclear facilities under IAEA safeguards, and conclude a zone free of weapons of mass destruction and delivery systems.

The NPT is likely to be helped by future verification technologies. The biggest threat to the treaty, however, comes from political changes. The most persistent criticism of the treaty is that it creates two categories of states, haves and have-nots, and assigns them different obligations and responsibilities. The commitment by the five declared nuclear weapons states to achieve nuclear disarmament has not been met and is unlikely to be fulfilled any time soon. The continued proliferation of chemical, biological, and nuclear weapons, and the threat that these weapons might fall into the hands of terrorists, slowly undermines the long-term viability of the regime. The nonratification of the Comprehensive Test Ban Treaty of 1996 by the United States is another challenge to the regime. Another potential challenge is the new U.S. nuclear and counterproliferation policy, which relies heavily on preemption, prevention, and first use. The United States also may develop new earth-penetrating mini-nukes, making the possibility of nuclear use more likely in future conflicts. This would break the taboo against their use in existence for over fifty years. The George W. Bush administration has been more focused on unilateral policies, and thus its support for multilateralist instruments such as the NPT is coming under strain. The demand by NNWS for effective security assurances, including a no-first-use pledge, is not being met by the NWS. The treaty is likely to survive as a somewhat weakened instrument as long as there are no other options in sight in the near future.

—T. V. Paul

See also: Arms Control; Disarmament; Threshold States

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NUCLEAR PLANNING GROUP

The origins of the Nuclear Planning Group (NPG) can be traced to U.S. Secretary of Defense Robert McNamara's Athens speech of 1962. In the aftermath of this speech, and following the demise of the European Multilateral Force idea and the adoption by the North Atlantic Treaty Organization (NATO) of the strategy of flexible response, the NPG was formed as a NATO forum for discussion of nuclear matters among the allies.

From the start there were disagreements within NATO over nuclear issues, and the French chose not to be a member of the NPG. At its first meeting, McNamara outlined the tasks he envisaged for the NPG. These included analyzing the threat from the Warsaw Pact and the research and development programs needed to develop weapons to meet emerging threats. McNamara also charged the NPG with sizing NATO's nuclear force structure and developing strategic and operational plans for the actual use of NATO's nuclear forces. The NPG did not offer European members of NATO control over nuclear weapons, nor did it provide a vehicle for other NATO states to have a veto over U.S. nuclear strategy. The United States retained control of NATO's plans for the employment of nuclear weapons in war. Instead, the NPG planned for the use of tactical and theater-level nuclear weapons. Decisions about the strategic use of nuclear weapons remained with the United States, and to a lesser degree, France and the United Kingdom.

Initially, membership in the NPG included four permanent members (the United States, the United Kingdom, West Germany, and Italy) and three rotating members. Nuclear-armed France was the obvious absentee from the NPG. Membership in the NPG was eventually opened to all NATO members, but today not all choose to participate in the NPG sessions. Sensitive issues involving NATO intermediate-force modernization in the late 1970s and 1980s also were limited to a NATO High-Level Group, which conducted studies for the NPG.

Since the end of the Cold War, the NPG has broadened its remit to encompass nonproliferation and the safeguarding of nuclear weapons, especially those found in the former Soviet Union. It has retained its mandate to update NATO's nuclear strategy, but its influence and importance have declined. Nevertheless, it still meets regularly and issues communiqués twice a year.

—Andrew M. Dorman

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NUCLEAR POSTURE REVIEW

In 1994 and again in 2001, the U.S. Congress directed the Defense Department to undertake a comprehensive Nuclear Posture Review (NPR) as a way to map out the future of American nuclear forces. Although it remains classified, the 2001 Nuclear Posture Review proposed profound changes in the composition and strategy governing U.S. nuclear forces. Linked to the new National Security Strategy and the latest Quadrennial Defense Review, the NPR offers a blueprint for transforming America's strategic posture.

The NPR calls for a new strategic "Triad" made up of conventional and nuclear offensive forces, missile defenses, and a robust nuclear infrastructure (*see* Triad). It downplays the role of Russia in U.S. strategic deterrence and highlights the need to deter and preempt emerging state and nonstate actors armed with weapons of mass destruction. Unlike the U.S. Cold War nuclear deterrent posture, which was intended to inflict massive damage against the Soviet Union under all conceivable circumstances, the NPR calls for a range of conventional and nuclear deterrence options to provide a credible deterrent across a wide range of scenarios.

The NPR is a complex and controversial document. On the one hand, it downplays the role of nuclear weapons and deterrence in the Russian-American strategic relationship, highlighting the need to make cooperation the cornerstone of Russian-American relations. The George W. Bush administration's decision to withdraw from the Anti-Ballistic Missile (ABM) Treaty is thus portrayed by the administration as an important step in eliminating the last vestiges of the Soviet-American Cold War relationship that was based on mutual assured destruction. On the other hand, the NPR calls for the integration of conventional and nuclear strike assets and missile defenses to generate credible deterrent and counterforce options against emerging threats posed by chemical, biological, and nuclear weapons. Critics charge that by calling for a new generation of low-yield earth-penetrating warheads to hold deeply buried targets at risk, the NPR will lower the nuclear threshold by making the battlefield use of nuclear weapons an increasingly attractive option to U.S. policymakers.

—Andrew M. Dorman

See also: Quadrennial Defense Review; United States Nuclear Forces and Doctrine

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NUCLEAR REGULATORY COMMISSION (NRC)

The Nuclear Regulatory Commission (NRC) is an independent U.S. government commission created by the Energy Reorganization Act of 1974. It is responsible for licensing and regulating the civilian use of nuclear energy to protect the public and the environment. The NRC also conducts public hearings on nuclear and radiological safety and on environmental and antitrust issues relevant to nuclear energy.

A five-member commission heads the NRC. The president of the United States designates one member to serve as official spokesperson and chairman. The commission formulates policies and regulations governing nuclear reactor and materials safety, issues orders to licensees, and adjudicates legal matters brought before it. As part of the regulatory process, the NRC's four regional offices conduct inspection, enforcement, and emergency response programs for licensees within their borders and investigate nuclear incidents.

Before the NRC was created, nuclear regulation was the responsibility of the Atomic Energy Commission (AEC), which Congress first established in the Atomic Energy Act of 1946. Congress replaced that law with the Atomic Energy Act of 1954. This act assigned the AEC the functions of both encouraging the use of nuclear power and regulating its safety (*see* Atomic Energy Act; Atomic Energy Commission).

During the 1960s, an increasing number of critics charged that the AEC's regulations were weak in terms of radiation protection standards, reactor safety, plant siting, and environmental protection. By 1974, Congress decided to abolish the AEC. Supporters and critics of nuclear power agreed that the promotional and regulatory duties of the AEC should be assigned to different agencies. In passing the Energy Reorganization Act of 1974, Congress created the NRC and transferred all of the licensing and regulatory powers of the AEC to the new agency. The NRC began operations on January 19, 1975.

—Steven Rosenkrantz

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NUCLEAR RISK REDUCTION CENTERS (NRRCs)

Nuclear Risk Reduction Centers (NRRCs) were established to reduce the risk of nuclear war between the United States and the Soviet Union resulting from accidents, miscalculations, or misinterpretations of world events. In September 1987, U.S. Secretary of State George P. Shultz and Soviet Foreign Minister Eduard Shevardnadze signed the agreement to establish the centers in Washington, D.C., and Moscow. The U.S. and Soviet centers opened on April 1, 1988, and their operations were authorized for an unlimited duration. The U.S. NRRC now operates seven communications systems that can establish communications with more than 100 countries, including the Russian Federation, Ukraine, Belarus, Kazakhstan, and most of the other member states of the Organization for Security and Cooperation in Europe.

The NRRCs' purpose is to exchange notifications required under existing and future security and arms control agreements and to undertake other security and confidence-building measures. The centers were not designed to duplicate the existing U.S.-Soviet "Hot Line," which was established in 1963 through a bilateral agreement. The Hot Line is reserved for communication between heads of state in times of emergency or crisis. The NRRCs have no crisis management role but were intended to help prevent crises by providing a way to exchange accurate information on a day-to-day basis. They are charged with the exchange, translation, and dissemination of the many government-to-government notifications required in the implementation of more than twenty different arms control treaties and security agreements.

Located in the two national capitals, the NRRCs are connected by dedicated, high-speed communications links. The centers are equipped with modern computers and are staffed with trained communication technicians. The U.S. Department of State's Bureau of Verification and Compliance is assigned responsibility for operating the U.S. NRRC.

—Steven Rosenkrantz

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NUCLEAR SUPPLIERS GROUP

The Nuclear Suppliers Group (NSG) is an organization of nuclear supplier nations voluntarily united in an effort to control the exports of certain materials and technologies that are dual-use—that is, items that could be used for either peaceful or weapons purposes. The goal of the group was to prevent the contribution of nuclear suppliers to the proliferation of nuclear weapons while not impeding legitimate international nuclear trade and technological cooperation.

The NSG, also known as the "London Club," was created in 1975 in response to a growing concern that tighter export controls of nuclear weapons–related materials were necessary. The environment was marked by concern that the first Indian nuclear detonation in 1974 would prompt an increase in global activities to obtain nuclear technology.

The NSG was conceived to limit the trade of dual-use materials and technologies to further the nonproliferation goals of the Nuclear Nonproliferation Treaty (NPT) of 1968. NSG guidelines serve to inhibit the progress of aspiring nuclear nations' programs by closing down reliable channels for supply and forcing them to seek alternative routes. This increases costs to these nations in their effort to pursue nuclear weapons development and also causes time delays (*see* Nuclear Nonproliferation Treaty [NPT]).

The 1971 Zangger Committee laid the groundwork for the Nuclear Suppliers Group (*see* Zangger Committee). The Zangger Committee's mission was to interpret the vague safeguard requirements of Article III.2 of the NPT, which addressed the export of nuclear equipment and material. Zangger Committee members entered into an ad hoc, voluntary agreement, which was not legally binding or formally connected to the NPT, in which they agreed not to export certain items without first ensuring that they would be safeguarded. Their "Trigger List" contained the items subject to safeguards. In 1978, the NSG prepared a set of guidelines, taking into consideration the Zangger Committee's Trigger List, and published it in International Atomic Energy Agency (IAEA) document INFCIRC/254. The NSG labeled its expanded list the "Critical Technologies List" (CTL). It has become a significant contribution to the current nuclear nonproliferation regime.

The membership of the NSG is larger than that of the Zangger Committee and further extended the latter's restrictions on nuclear trade. A strong tool of the NSG is the exchange of information amongst the thirty-four members to increase awareness of potential weapons proliferation.

Restrictions on trade include:

- Strict security arrangements for nuclear exports;
- A consent requirement from the original supplier in case of reexport;
- Withholding of critical materials and technologies used for uranium enrichment, plutonium reprocessing, fuel fabrication, and heavy-water production equipment and plants from export to countries of concern; and
- Full-scope safeguards for supply to any non–nuclear weapons state.

The NSG also controls a second tier of transfers regarding technology and materials that are not exclusively used for nuclear purposes but could make critical contributions to a nation's nuclear fuel cycle. These technologies are prevalent in nonnuclear industries.

In 1992, in response to lessons learned from revelations of the extent of the Iraqi nuclear program, the NSG extended its CTL to encompass an even broader definition of dual-use items related to the nonnuclear elements of nuclear weapons development. Evidence mounted that Iraq's progress toward the building of a nuclear weapons infrastructure was being achieved through purchases of dual-use technologies and materials from unwitting suppliers (*see* Iraqi Nuclear Weapons Program).

The CTL is an extensive list but it has limitations. It does not cover all potentially nuclear-relevant technologies useful for the construction of a nuclear weapons infrastructure. It includes all key categories of nuclear-related dual-use technologies, but some of the foundational technologies that are components of these key categories are simply too ubiquitous to be easily controlled. Although common in many industries and considered to be too unimportant in the past to merit much scrutiny, the trade of these items has aided some nations with nuclear aspirations.

The NSG suffers from other limitations. For one thing, its membership is not comprehensive. Nations such as India, Israel, and Pakistan are notable nonmembers. The group itself does not have implementation provisions, so member nations individually incorporate the NSG guidelines into their national export controls in a manner of their choosing. Responsibility for implementing the NSG is left to the member nation and requires self-policing.

—Jennifer Hunt Morstein

See also: Dual Use; International Atomic Energy Agency; Nonproliferation; Proliferation

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NUCLEAR TABOO

The nuclear taboo is a norm that makes the leaders of nuclear-armed states almost unthinkingly rule out the employment of nuclear weapons. Perhaps the most notable characteristic of nuclear weapons is that they have not been used in conflict since the United States dropped two atomic bombs on Japan to end World War II. Why no nuclear weapons have been used in combat since 1945 is a matter of controversy. Several conditions could explain the nonuse of nuclear forces: deterrence; lack of suitable targets; availability of other military options; or constraints created by public opinion, luck, or a normative inhibition against inflicting nuclear devastation. The last factor is called the "nuclear taboo."

The armed forces of all nuclear weapons states plan and train to use nuclear forces under certain contingencies, but the use of these weapons has been most seriously considered only a few times, such as during the Korean and Vietnam wars and the Cuban missile crisis. After considerable debate, U.S. officials ruled out nuclear use during these crises mainly out of fear of provoking direct military conflict with the Soviet Union, although moral and political considerations also mattered. In the aftermath of these episodes, U.S. policymakers made it a priority to avoid circumstances in which the president would have to contemplate nuclear use.

It is difficult to know just how strong and universal the nuclear taboo has become. The normative constraint against nuclear use probably grows stronger with the passage of time since the last nuclear detonation. The next use of nuclear weapons, particularly if that use is deemed effective, however, could seriously erode the taboo and make the possession of nuclear weapons more desirable and their use more thinkable.

—Peter Lavoy

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NUCLEAR TEST BAN

The first nuclear test took place in July 1945 when the United States tested an atomic bomb at the Trinity Test Site in New Mexico. Since then, almost 2,000 nuclear tests have been conducted around the globe. When Indian Prime Minister Jawaharlal Nehru first called for a "standstill" agreement on nuclear testing in April 1954, many governments and much of world opinion backed this sentiment. The United States, the Soviet Union, and the United Kingdom began discussions about the scope and nature of a nuclear test ban in Geneva in October 1958. The process became bogged down over verification procedures, however, and was soon placed on the diplomatic back burner as East-West tension rose in the early 1960s (*see* Underground Testing).

Nevertheless, tripartite negotiations in Moscow in the summer of 1963 produced the Limited Test Ban Treaty (LTBT), which came into force on October 11, 1963. The LTBT banned nuclear tests in the atmosphere, under water, or in space and contained a clear commitment to work toward prohibiting underground tests, as did the preamble to the 1968 Nuclear Nonproliferation Treaty (NPT). Further partial bans followed. The 1974 Threshold Test Ban Treaty (TTBT) limited underground tests to yields of less than 150 kilotons, and the Peaceful Nuclear Explosions Treaty of 1976 imposed a similar ban on nonmilitary tests. Both the LTBT and the TTBT anticipated a complete test ban, but negotiations on such a ban between 1977 and 1980 failed (*see* Limited Test Ban Treaty; Nuclear Nonproliferation Treaty; Peaceful Nuclear Explosions Treaty; Threshold Test Ban Treaty).

It was not until 1993, with strong support from the United Nations General Assembly, that negotiations for a comprehensive treaty began. These would ultimately produce the Comprehensive Test Ban Treaty (CTBT), which prohibits all nuclear test explosions in all environments. The CTBT was opened for signature in September 1996, when it was signed by seventy-one states, including the five nuclear weapons states. Although President William Clinton signed the CTBT, the U.S. Senate has failed to ratify the agreement.

—J. Simon Rofe

See also: Comprehensive Test Ban Treaty

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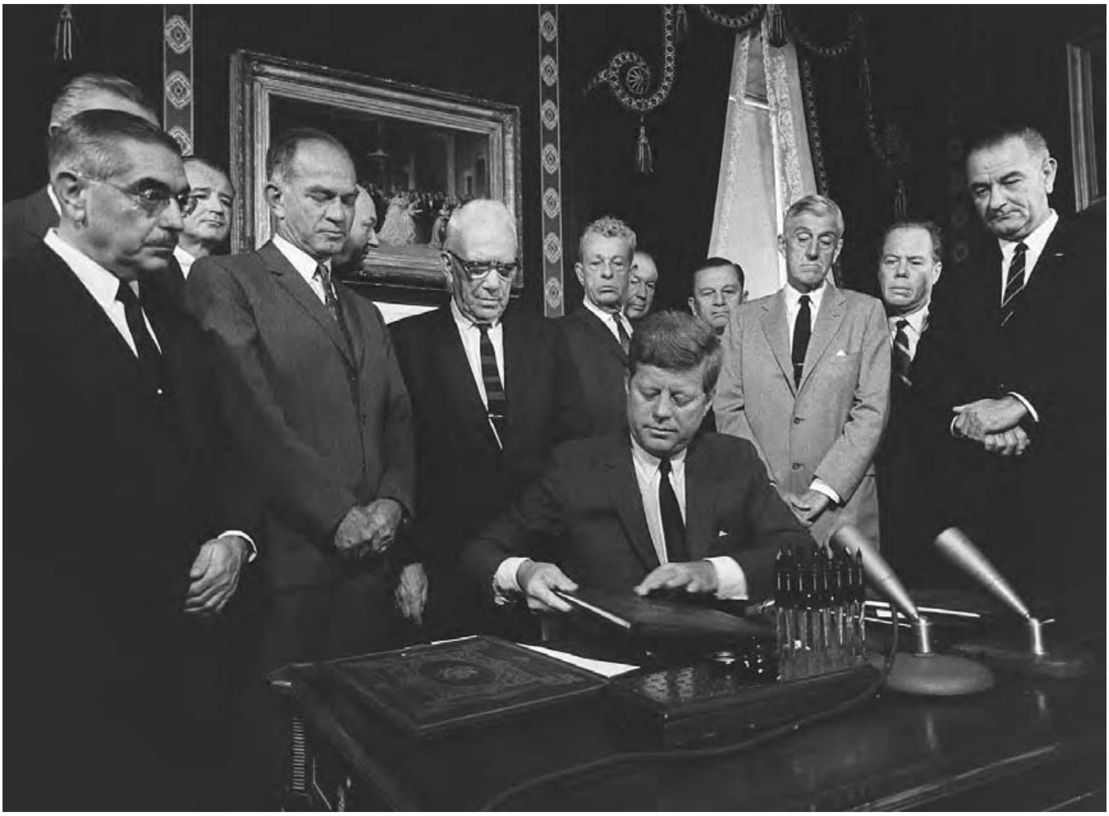

President John F. Kennedy signing the Limited Test Ban Treaty, October 7, 1963. (National Archives)

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NUCLEAR WARHEAD STORAGE AND TRANSPORTATION SECURITY (RUSSIA)

Despite occasional claims since 1989 that nuclear warheads inherited by the Russian Federation from the Soviet Union are missing, that Russian officers have sold warheads on the black market, or that warheads have been stolen from storage depots, no credible evidence exists to support these allegations. Nonetheless, the Russian Ministry of Defense has not been sheltered from Russia's general economic and social problems. Historically, Russia has relied heavily on guard forces, and its transition to technological solutions to defense and security problems has been slow. With persistent personnel reliability issues, security concerns remain, and international efforts to provide Russia with nuclear security enhancements assistance have met with limited progress.

Russia currently possesses an arsenal of 18,000 to 20,000 nuclear warheads. Within the Ministry of Defense, the Twelfth Main Directorate (or 12th GUMO, for Glavnoye Upravleniye Ministerstvo Oborony) of the General Staff is in charge of ensuring the safety, security, accountability, and functionality of the military's nuclear munitions. The 12th GUMO issues regulations governing the security and accountability of all Russian warheads and manages those functions for all nondeployed warheads. For deployed warheads, 6th Directorates within each military service—Navy, Air Force, and Strategic Rocket Forces—are in charge of security functions and coordination with the 12th GUMO.

Few of Russia's nuclear warheads are mated to delivery systems (intercontinental ballistic missiles, submarine-launched ballistic missiles, air-launched cruise missiles, and gravity bombs). From a proliferation perspective, operationally deployed warheads are the most secure. Deployed weapons are subject to constant physical and electronic scrutiny, are kept within militarily secured perimeters, and are the most difficult to remove clandestinely and without substantial equipment and personnel.

The majority of Russia's nuclear warheads are not deployed. These warheads are either in long-term central storage facilities, in short-term storage facilities at or near deployment bases, at assembly or disassembly plants, or in transit between these sites. Perhaps the most significant security enhancement Russia has undertaken recently was to reduce the number of storage depots from more than 500 in the late 1980s to fewer than 100 by the late 1990s. Each facility may contain one or several bunkers of various sizes and store from a few spares to several hundred warheads. All facilities are secured through physical protection, electronic measures, and guard forces. An outer perimeter provides the first physical barrier to a facility. Each bunker is then individually secured with several layers of sensored and nonsensored fencing plus a comprehensive suite of equipment that may include command and control systems; closed-circuit television; interior and exterior intrusion detection systems; rapidly deployable sensor systems; fire and safety systems; access control; vehicle and personnel barriers and access delay systems; and hazardous or prohibited material detection systems. The Ministry of Defense assigns the responsibility of each warhead to one officer, and warheads may only be accessed by a minimum of three officers (enlisted personnel are not permitted to access the warheads). On-site guard forces are supplemented by proximate response teams.

Russia does not transport its nuclear warheads by air. Rather, it uses special trucks for local movements and the railways for long-distance transports. In special cases, for example in 2000 when Russia transferred warheads to Kaliningrad, Russia may use surface ships to move warheads over sea routes. Prior to transport, warheads are wrapped in armored blankets and placed in special containers. These supercontainers provide thermal and ballistic protection as well as an additional measure of security owing to their size and weight. Transportation routes are classified and managed by the Ministry of Railways, and each train is accompanied by a guard force contingent.

—*Charles L. Thornton*

See also: Russian Nuclear Forces and Doctrine

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NUCLEAR WEAPONS EFFECTS

The principal effects of nuclear weapons are thermal radiation, blast, nuclear radiation, and electromagnetic pulse (EMP). The severity of these effects depends on the yield (size) of the weapon (expressed in kilotons or megatons), the design of the weapon, and the way it is employed. Fifty percent of the energy from a low-altitude atmospheric detonation of a moderate-sized nuclear weapon is in the form of blast, and 35 percent is in the form of thermal radiation. Radiation accounts for 15 percent of the destructive force from this type of explosion. Five percent of this radiation takes the form of initial radiation (neutrons and gamma rays), which is emitted within the first minute after detonation, and 10 percent is in the form of residual nuclear radiation, which is primarily fallout. EMP does not come directly from the detonation itself but is a secondary effect created by the interaction of nuclear radiation with the Earth's atmosphere.

Technical Details

Two ounces of uranium 235 (U-235), fully fissioned, will yield the equivalent explosive power of 2 million pounds of trinitrotoluene (TNT) high explosive. Because of these large equivalent values, nuclear weapon yields are expressed in terms of kilotons and megatons. One kiloton is the energy equivalent of 1,000 tons of TNT, and 1 megaton is the energy equivalent of 1 million tons of TNT (*see* Kiloton; Megaton).

The altitude at which the nuclear weapon is detonated influences the relative effects of blast, thermal radiation, nuclear radiation, and EMP. Altitude refers not only to the height of the burst, but also to whether the fireball from the burst comes in contact with the Earth's surface. The term "fireball" refers to the luminous sphere of hot gases that forms a few millionths of a second after the detonation of a nuclear weapon and immediately starts expanding and cooling. Nuclear explosions are thus classified as high-altitude bursts, airbursts, surface bursts, and subsurface bursts. See Table N-1.

A high-altitude burst occurs when a weapon is detonated at an altitude greater than 30 kilometers.

Table N-1: Summary of Nuclear Weapon Effects

Effect	*Percentage of Nuclear Burst Energy*	*Products*
Thermal radiation	35%	Heat, fire, burns
Blast	50%	Shock wave
Residual radiation	10%	Fallout, neutron-induced gamma activity
Initial radiation	5%	Casualities
Electromagnetic pulse (EMP)	0%	No known biological effects; extensive damage to electronics

Source: Joint Chiefs of Staff WMD Handbook.

This type of detonation produces a very large fireball that expands rapidly. At this altitude, EMP will be the dominant nuclear weapons effect.

An airburst occurs when a nuclear weapon is exploded in the atmosphere at an altitude of less than 30 kilometers. The fireball produced by the detonation does not contact the surface of the Earth. Although initial radiation will be significant, the residual radiation (fallout) hazard is minimal. Burns to exposed skin and eye injuries can occur. Fission products will be dispersed over a large area, and neutron-induced radiation will concentrate around ground zero (*see* Ground Zero; Neutrons). EMP will cause major damage to electronic systems.

A surface burst occurs when the weapon is detonated on or slightly above the surface so that the fireball actually contacts the Earth. The area affected by the blast, thermal radiation, and initial nuclear radiation will be less extensive than for an airburst. Destruction is concentrated at ground zero. In contrast to an airburst, a ground burst produces an extreme amount of fallout that extends well beyond the area affected by blast and thermal radiation.

A subsurface burst occurs beneath land or water. This type of detonation might occur in a subway, in the basement of a building, or under water in a harbor or port. This type of detonation generally produces a large crater. If the burst does not penetrate the surface, the only hazard will be from ground or water shock. If the blast penetrates the surface, effects will be present, but less than for a surface burst of similar yield. Local fallout will be heavy.

A low-order nuclear reaction that creates only a minor explosion but releases a burst of radiation is called a fizzle. A weapon designed improperly or physically damaged may, when triggered, begin producing a chain reaction. But as the nuclear events begin to occur to sustain that chain reaction, improper physical positioning introduces inappropriate elements into the fission process. For instance, a moderator used to reflect neutrons back into the core may itself have been forcefully injected into the core by a physical event (such as the bomb hitting the ground). This stops the reaction before it ever develops into a sustained chain reaction. Misshaped cores, misdirected compression explosions, and many other events cause the reaction to fizzle out. When this occurs, many of the effects usually associated with a nuclear detonation fail to materialize.

Thermal Radiation

Thermal radiation is the heat and light produced by the nuclear explosion. Thermal radiation travels in a straight line at the speed of light, can be easily absorbed or attenuated, and can be scattered or reflected. When a nuclear weapon is detonated, burns from the thermal radiation are the most common injury among casualties from the blast. The thermal radiation emitted by a nuclear detonation causes burns in two ways: by the direct effect on exposed body surfaces (flash burns), and from the fires started by the flash (flame burns). The relative importance of these two processes will depend on the environment. If a nuclear detonation occurs in inflammable surroundings, indirect flame burns could outnumber all other types of injury. Because of the complexity of burn treatment and the increased logistical requirements associated with the management of burns, they constitute a difficult problem for medical personnel.

Since the thermal pulse is direct infrared energy, flash burn patterns on the body will be determined by spatial relationships and clothing pattern absorption. Exposed skin will be burned on the side facing the explosion. Persons shaded from the direct light of the blast are protected. Light colors will reflect the infrared, while dark portions of clothing will absorb it and cause pattern burns. Records from the Hiroshima and Nagasaki bombings indicate that, in some cases, dark-colored clothing actually bursts into flames. At temperatures below those required to ignite clothing, it is still possible to transfer sufficient thermal energy through clothing to the skin to produce flash burns; however, clothing significantly reduces the risk of flash burns.

Flame burns result from exposure to fires caused by thermal radiation igniting surrounding structures, vehicles, and a person's clothing. Firestorm and secondary fires will cause flame burns, but they will be aggravated by closed-space fire injuries. Patients with toxic gas injury from burning plastics and other material, superheated air inhalation burns, steam burns from ruptured pipes, and all other similar injuries will require treatment. Complications arise in the treatment of skin burns created, in part, from the melting of synthetic fibers.

Since the majority of people caught in a nuclear environment will not be wearing protective goggles, eye injuries will occur. Factors that determine the extent of eye injury include pupil dilation, spectral transmission through the ocular media; spectral absorption by the retina and choroid; and length of time of exposure. Optical equipment such as binoculars will increase the likelihood of damage. Other eye injuries include flash blindness and retinal burns.

Blast

The majority of material damage caused by a nuclear explosion is due to the blast wave that accompanies the explosion. The blast wave is a brief and rapid movement of air vapor away from the fireball. It is characterized by sharp pressure increases and winds. At a fraction of a second after a nuclear explosion, a high-pressure wave develops and moves outward from the fireball. This is the blast wave. The front of the blast wave, called the shock wave, travels rapidly away from the fireball and behaves much like a moving wall of highly compressed air. When the blast wave strikes the surface of the ground, it is reflected back, similar to a sound wave producing an echo. This reflected blast wave, like the original (or direct) wave, is also capable of causing material damage. The reflected wave eventually catches up with and reinforces the direct wave.

A phenomenon called the "mach stem" may accompany an airburst. The mach stem is formed as a result of the reflected wave traveling more rapidly within the heated medium of the incident wave. Pressures and wind velocity from the mach stem are considerably higher than from the primary shock wave alone. The blast wave initially travels at speeds seven to eight times that of sound, but its strength diminishes rapidly until the wave approaches the speed of sound. The maximum pressure will occur the moment the blast wave arrives at a given location.

Pressure will begin to drop off immediately after the initial blast pulse passes. If the reflected wave has not caught the incident wave at a particular location, two pressure increases will be experienced—the first from the incident wave, and the second from the reflected wave. At a certain distance from ground zero, a negative phase of the blast wave will develop. Winds in the negative phase are lower than in the positive phase. The negative phase is caused by air rushing in to replace the rising fireball and the cooling of the heated air around ground zero. As this gas cools, the pressure decreases and can drop up to 4 pounds per square inch below normal atmospheric pressure. The negative phase is not considered a significant damaging effect. The pressure resulting from winds (mass airflow) directly behind the shock front is called "dynamic pressure." These winds affect damage to drag targets, that is, targets dragged along, set into a rolling motion, or torn apart by wind.

The direct blast wave overpressure force is measured in terms of atmospheres of overpressure. When this blast wave acts directly upon the human body, rapid compression and decompression result in transmission of pressure waves through the tissues. These waves can be quite severe and will result in damage primarily at junctions between tissues of different densities (bone and muscle) or at the interface between tissue and air spaces (lung tissue and the gastrointestinal system). Perforation of the eardrums will be a common blast injury. The range of overpressures causing deaths can vary greatly. It is important to note that the human body is remarkably resistant to direct blast overpressure, particularly when compared to rigid structures such as buildings.

The indirect blast wind drag force is measured in the velocities of the winds created by the detonation. These winds vary with distance from the point of detonation, yield of the weapon, and altitude of the burst. The winds are of relatively short duration but are extremely severe and may reach speeds of several hundred miles per hour. Indirect blast injuries will result when individuals are thrown against immobile objects and impaled by flying debris. Broken bones and head injuries will be commonplace. The distance from the point of detonation at which severe indirect injury will occur is considerably greater than that for serious direct blast injuries (*see* Yield).

Nuclear Radiation

All nuclear detonations will create neutron, gamma, beta, and alpha radiation. This radiation is categorized as either initial radiation or residual radiation. Neutron and gamma radiation are present in the initial burst, while alpha, beta, and gamma rays make up the residual radiation.

Approximately 5 percent of the energy released in a nuclear airburst is transmitted in the form of initial neutron and gamma radiation. The neutrons result almost exclusively from the energy produced by fission and fusion reactions. Initial gamma radiation is produced by these reactions as well as from the decay of short-lived fission products. The intensity of the initial nuclear radiation decreases rapidly with distance from the point of burst. The character of the radiation received at a given location also varies with distance from the explosion. Near the point of the explosion, the neutron intensity is greater than the gamma intensity, but it reduces quickly with distance. The range for significant levels of initial radiation does not increase markedly with weapon yield. Therefore, the initial radiation becomes less of a hazard with increasing yield, as individuals close enough to be significantly irradiated are killed by the blast and thermal effects.

Residual radiation from a nuclear explosion is primarily radioactive fallout. In a surface burst, large amounts of earth or water will be vaporized by the heat of the fireball and drawn up into the radioactive cloud, especially if the explosive yield exceeds 10 kilotons. This material becomes radioactive and is dispersed by the wind. It will eventually settle to Earth as fallout. The larger particles will settle as local fallout within twenty-four hours. Severe local fallout contamination can extend far beyond the blast and thermal effects, particularly in the case of high-yield surface detonations (*see* Fallout; Radiation).

Electromagnetic Pulse

EMP does not result directly from the detonation itself but is a secondary effect created by the interaction of specific nuclear radiation with the Earth's atmosphere. It is essentially a very strong radio signal of short duration. If the burst point of the nuclear explosion is greater than 30 kilometers in altitude, the EMP will cover a very large area (thousands of square kilometers). The effects of EMP from a surface or low-altitude nuclear burst will extend about as far as the other weapon effects. EMP can produce a current in any electrical conductor and temporarily disrupt or damage all electrical components not properly protected. EMP must be taken into consideration in any scenario involving the threat of nuclear weapons. There are no known biological effects of EMP; however, indirect effects may result from the failure of critical medical or transportation equipment.

Radioactive Contamination Hazards

Radioactive material released into an area can pose both internal and external contamination hazards to people living there. External hazards are generally associated with skin contamination and increased probabilities of internal contamination. Internal contamination hazards are associated with the exposure of internal organs to radioactive material that has been taken into the body via inhalation, ingestion, or absorption through the skin or a wound.

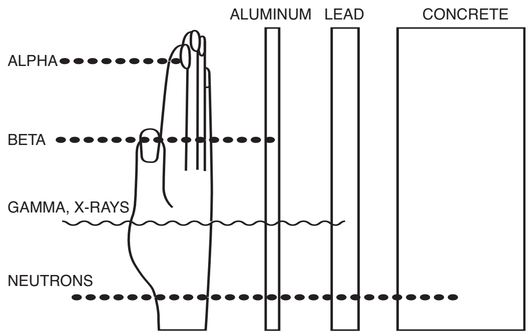
Significant amounts of radioactive material will be deposited on ground surfaces as well as on people by nuclear weapons and radiological dispersal devices (RDDs). Destruction of nuclear reactors, nuclear accidents, or the improper disposal of radiological waste also can contaminate the environment. Lethal doses of external radiation can occur if protective measures are not taken.

Fallout may be deposited onto clothing and/or skin and may enter the body. In a nuclear reactor accident, radionuclides may enter the body through wounds or by the inhalation of radioactive gases or particulate matter. Radioactive material that falls onto food or into the water supply could be ingested. A source of exposure is radioactive material that has entered the food chain, such as occurred in Europe following the Chernobyl accident (*see* Chernobyl). Other sources of internal contamination are by medical mistake or the ingestion of radioactive materials from an RDD.

Shielding

Shielding is any material or obstruction that absorbs or attenuates radiation, thereby reducing radiation

Figure N-3: Shielding for Various Types of Radiation



exposure. Alpha radiation has heavily charged particles with a very low airborne range. Unbroken skin stops these particles. Light clothing and gloves will also provide protection. Problems arise when the particles enter the body through a break in the skin, via contaminated food, or through breathing.

Although airborne beta particles can travel significant distances, solid materials stop them. A sheet of aluminum will stop beta emissions. Beta emitters present two potential external radiation hazards: the beta particles themselves, and the X-rays they can produce when they strike certain materials, such as lead. Although beta particles can travel significant distances in air, materials such as aluminum, plastic, or glass can provide appropriate shielding. Because the lens of the eye is radiosensitive, eye protection such as goggles or a protective mask is recommended if exposure to beta particles is likely.

Gamma radiation is highly penetrable and could present a hazard. Protection from gamma radiation depends on the type, density, and thickness of the shielding. As the thickness of the shielding increases, the gamma radiation will decrease. Lead, tungsten, concrete, and steel can be used as shielding from gamma emissions (see Figure N-3).

—*Jeffrey A. Adams*

See also: Fission Weapons; Hydrogen Bomb; Neutron Bomb (Enhanced Radiation Weapon); Nuclear Winter; Thermonuclear Bomb; Weapons of Mass Destruction

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NUCLEAR WEAPONS FREE ZONES (NWFZS)

Nuclear weapons free zones (NWFZs), which mandate the complete prohibition of nuclear weapons within a distinct geographic area, are steps toward a nuclear weapons–free world. NWFZs are an instrument of both nonproliferation and disarmament, causing states to abandon their nuclear weapons programs. In the case of Argentina and Brazil, this occurred before nuclear weapons development had progressed to the point of having a nuclear weapons capability. In the case of South Africa, the emergence of an NWFZ helped a state dismantle the nuclear weapons it possessed.

There are six NWFZs in the world today, and two more zones are in the process of forming. Most of the NWFZs have been created by regional treaties. Mongolia (2000) and Austria (1999), however, declared their nuclear weapons–free status through domestic laws, thus creating single-state zones. New Zealand, though a member of the South Pacific NWFZ, still enacted strong domestic legislation creating its own NWFZ in 1987. The constitution of the Philippines also forbids the placement of nuclear weapons on its territory.

The regional NWFZ treaties share several provisions. All of the treaties prohibit the member states from manufacturing, producing, possessing, testing, acquiring, receiving, and deploying nuclear weapons. They also include provisions for security assurances from nuclear weapons states to treaty members.

History and Background

The first regional treaty banning nuclear weapons from a region was the Antarctic Treaty, which opened for signature on December 1, 1959, and entered into force on June 23, 1961. The treaty forms the Antarctic Treaty Area, which covers everything south of the latitude 60°S. The treaty was meant to ensure that "Antarctica shall continue to be used exclusively for peaceful purposes and shall not become the scene or object of international discord." The Treaty for the Prohibition of Nuclear Weapons in Latin America (and the Caribbean) is also known as the Tlatelolco Treaty. Signed on February 14, 1967, and entered into force on April 22, 1968, it calls for the creation of the Agency for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (OPANAL) in Mexico City, Mexico. The words "and the Caribbean" were added to the title of the treaty in July 1990. Cuba became the final Latin American state to ratify the treaty on October 23, 2002.

The South Pacific Nuclear Free Zone Treaty, also is known as the Treaty of Rarotonga, was signed on August 6, 1985, and entered into force on December 11, 1986. Thirteen states are full members to this treaty: Australia, Cook Islands, Fiji, Kiribati, Nauru, New Zealand, Niue, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu. The five nuclear weapons states (China, France, the Russian Federation, the United Kingdom, and the United States) are all adhering to the treaty's protocols.

Unlike the Tlatelolco Treaty, the Treaty of Rarotonga bans nuclear explosions and explosive devices for peaceful purposes from the territory covered by the treaty and bans the dumping of nuclear waste in the regional seas. Furthermore, the Treaty of Rarotonga established that the director of the South Pacific Bureau for Economic Co-operation would be responsible for the implementation of the treaty, monitoring compliance and issuing reports.

The Treaty on the Southeast Asia Nuclear Weapon Free Zone, also known as the Bangkok Treaty, was signed on December 15, 1995, and entered into force on March 28, 1997. This NWFZ covers Brunei, Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. It also includes all of their continental shelves and maritime exclusive economic zones. The treaty calls for the organization of a commission for the Southeast Asia Nuclear Weapon Free Zone that may meet in conjunction with the Association of Southeast Asian Nations (ASEAN) Ministerial Meeting.

The Treaty for the Nuclear Weapons Free Zone in Africa is known as the Pelindaba Treaty. It covers the continent of Africa, island states members of the Organization of African Unity (OAU), and all islands considered by the OAU to be part of Africa. The treaty was signed on April 11, 1996. Along with the provisions similar to those set forth in other regional treaties, the Pelindaba Treaty prohibits any armed attack on nuclear installations. It calls for the Organization of the African Commission on Nuclear Energy as the mechanism for compliance. The members to the treaty report to the commission and engage in exchanges of information.

At the same time as the signing of the Pelindaba Treaty, Egypt authored the "Cairo Declaration" to state that the signing of the Pelindaba Treaty was a positive step for nonproliferation and that it was "a highly significant contribution to the enhancement of international peace and security." Furthermore, acting within the scope of Egypt's typical role at nonproliferation discussions, it was emphasized in the declaration that "the establishment of nuclear-weapons-free-zones, especially in regions of tension, such as the Middle East, on the basis of arrangements freely arrived at among the states of the regions concerned, enhances global and regional peace and security."

Current Status

Only one of the regional treaties has been ratified by every country within its zone, and a number of protocols to the treaties need to be joined by the nuclear weapons states. There is no Middle East Nuclear Weapons Free Zone (MENWFZ), although it was an initiative pushed by Egypt that has yet to come to fruition. The plans for a Central Asian Nuclear Weapons Free Zone (CANWFZ), which will include Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, started with the Almaty Declaration of February 28, 1997. Many drafts of a CANWFZ accord have circulated within the United Nations, and on September 27, 2002, a UN-sponsored Expert Group, which had contributed to the formulation of a treaty text, concluded its negotiations on the text. On October 8, 2002, the UN Department for Disarmament Affairs had its first consultative meeting to gain the agreement of the permanent members on the Security Council to extend the negative security assurances that are part of the protocol that is annexed to the treaty.

—*Kimberly L. Kosteff*

See also: Antinuclear Movement; Arms Control; Negative Security Assurances; Proliferation; Rapacki Plan

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NUCLEAR WEAPONS STATES

The Nuclear Nonproliferation Treaty (NPT) of 1968 defined a nuclear weapons state (NWS) as one that had manufactured and exploded a nuclear weapon or other nuclear device by January 1, 1967. This limited the list of nuclear weapons states to five countries: the United States, the Soviet Union (now Russia), France, the United Kingdom, and China.

Although these five states are the only legally recognized nuclear weapons states, there are certainly more states with nuclear weapons. In fact, India, Pakistan, and Israel, the only three major countries that remain outside of the NPT, are also de facto nuclear weapons states.

Nuclear weapons states have many obligations that are defined by international law. The nuclear weapons states that signed the NPT agree not to transfer nuclear weapons or control over them to any non–nuclear weapons state or to assist non–nuclear weapons states in the manufacturing of nuclear weapons. Additionally, nuclear weapons states are obligated to accept international safeguard systems implemented and monitored by the International Atomic Energy Agency (IAEA) for all of their peaceful nuclear programs. As of 2001, IAEA safeguard agreements are in place with 142 states. Finally, the five nuclear weapons states agreed to move toward general nuclear disarmament.

—Abe Denmark

See also: Disarmament; International Atomic Energy Agency; Negative Security Assurances; Nonproliferation; Nuclear Nonproliferation Treaty; Proliferation; Strategic Forces; Threshold States

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NUCLEAR WINTER

"Nuclear winter" is a term referring to the environmental disaster that some scientists believe would occur following a full-scale nuclear war. According to the nuclear winter theory, the cumulative effects of extreme heat, blast, radiation, and dust thrown into the air in such an exchange would destroy the ozone layer and block the sunlight needed to warm the Earth. The effect would be global and perhaps result in the extinction of most forms of life on Earth.

Several studies on the possibility of nuclear winter were conducted in the 1970s, the most famous being the 1983 TTAPS (Turco, Toon, Ackerman, Pollack, and Sagan) study. This particular study took into account various factors such as forest fires, burning fossil fuels, and intense smoke covering the Earth for periods lasting for weeks or months. The authors of the study further postulated that a period of darkness would exist that could plunge average temperatures by as much as 40 degrees Fahrenheit (thus, the term "nuclear winter"). Many scientists disputed the idea of a nuclear winter, saying that it did not follow normal meteorological processes and that the smoke would not stay aloft for so great a time. In 1990, a more detailed study (TTAPS 1990) was conducted with extensive meteorological modeling. Although the new study revealed that between 10 and 25 percent of the ejected soil would fall to the ground by immediate precipitation (black rain, such as was seen at Hiroshima), it also showed that the smoke would spread through different hemispheres, reducing temperatures within one to two weeks. The long-term effects of a nuclear winter could last from one to two years and kill an estimated 1 to 2 billion people.

Since the fall of the Soviet Union and the slashing of strategic arsenals, nuclear winter studies have become passé. Almost all of them were based upon a nuclear exchange in the 5,000-megaton range, which now seems both politically implausible and beyond the deployed nuclear capability of Russia and the United States. It is now believed by many that nuclear exchanges in the twenty-first century would involve considerably less explosive power and relatively small nuclear weapons that would be targeted with great precision—perhaps fewer than ten weapons of 100 kilotons or smaller. Although these would have devastating local results, they would have no significant impact on global weather patterns. One area where the TTAP studies have made a lasting useful impact was in studying the effects of an asteroid impact on Earth. The impact of large asteroid on Earth would not generate residual radiation, but the widespread fires and dust ejected into the atmosphere could easily exceed the nuclear winter effect created by a large-scale nuclear exchange.

—*Zach Becker*

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NUNN-LUGAR COOPERATIVE THREAT REDUCTION ACT

See Cooperative Threat Reduction (The Nunn-Lugar Program)

O

OAK RIDGE NATIONAL LABORATORY

Oak Ridge National Laboratory was established in eastern Tennessee in 1942 to serve as one of the development sites for the Manhattan Project. The lab's primary wartime mission was the production of uranium 235 for use in atomic weapons. It was home to the first graphite reactor, which was used as a model for the larger production reactors built at Hanford, Washington, to create plutonium. Today, the Oak Ridge National Laboratory has developed into a multipurpose organization (*see* Hanford, Washington; Manhattan Project; Plutonium).

Originally a secured area with a wartime population of 75,000 people, by 1946 Oak Ridge had become the world's foremost source for radioisotopes for medicine, agriculture, and industry. After the war, the area was privatized, and a town was developed and incorporated in 1959.

Uranium fission was discovered by two German scientists in 1939. By 1942, the U.S. War Department had launched the Manhattan Project to create the nuclear bomb under the scientific leadership of Robert Oppenheimer and Enrico Fermi. To create a nuclear weapon, an adequate supply of fissile material had to be manufactured. Oak Ridge National Laboratory was created to pioneer methods of producing highly enriched uranium (HEU) and producing and separating plutonium, a product of uranium neutrons freed by the fission chain reaction and captured by uranium atoms. In addition to perfecting plutonium reprocessing, the Oak Ridge lab created enough highly enriched uranium to power the "Little Boy" atomic bomb that was dropped on Hiroshima on August 6, 1945. The HEU was produced at K-25, a gaseous-diffusion plant at Oak Ridge that was closed in 1985. Another plant, Y-12, continues to do weapons- and nonweapons-related work, including recycling of nonfissile components of decommissioned warheads (*see* Highly Enriched Uranium; Little Boy; Uranium).

The Oak Ridge National Laboratory currently covers 58 square miles and has a staff of 3,800, including 1,500 scientists and engineers. One current research focus of the laboratory is the exploration of sources of clean energy. Radioactive pharmaceuticals, electronic instrumentation, and basic science are also current research areas, and the laboratory is a leading center for work on neutron science, energy, high-performance computing, complex biological systems, and advanced materials.

—Frannie Edwards and Jeffrey A. Larsen

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ON THE BEACH

On the Beach was an antiwar novel by Nevil Shute, published in 1957, which had a dark influence on the early nuclear age. It was later made into an acclaimed movie. It tells the story of the survivors of an accidental global nuclear war that has killed everyone in the Northern Hemisphere. Shute depicts a world in which even Third World countries possess nuclear weapons, and in the story it is a nuclear exchange between Third World countries that eventually draws the world's superpowers, the United States and the Soviet Union, into the conflict. The massive nuclear exchange between the superpowers, consisting mainly of fictional hydrogen "cobalt bombs" meant to create massive radioactive fallout, leaves the Northern Hemisphere, where the vast majority of nuclear detonations occurred, devoid of life.

The world's only survivors live in the Southern Hemisphere, and global weather patterns have yet to bring radioactive fallout to this part of the world. The four main characters of the novel are living out their last seven months of life in Falmouth, Australia. This is the length of time the fictional scientists expect that it will take for global winds to bring the fallout to Australia. The reader follows the characters as they live out their last days, coping with the knowledge that their time is limited. One couple, married with a new baby, plants a garden for the following spring even though they will have died by then. Another character has become an alcoholic. The last is a U.S. Navy submarine commander who ended up in Australia after the war and is in a state of denial, refusing to come to grips with the fact that his wife and children in Connecticut are dead. In the end, each must decide for him or herself whether to die a painful death from radiation poisoning or to commit suicide by taking the cyanide caplets that have been provided by authorities.

Shute provides an ironic and anticlimactic vision of the way the world might end in the event of global nuclear war. But his book provides insight into the existential fear of nuclear Armageddon that gripped much of the planet during the Cold War. It is a vision that takes its cue from the T. S. Eliot quote found on the title page of the book: "This is the way the world ends; Not with a bang but a whimper."

The 1959 movie *On the Beach* was directed by Stanley Kramer and starred Gregory Peck, Ava Gardner, Fred Astaire, and Anthony Perkins.

—*Sean Lawson*

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ONE-POINT DETONATION/ ONE-POINT SAFE

One-point detonation, common in early versions of nuclear weapons, was a design feature of high-explosive systems whereby the detonation was initiated at a single point. It has been replaced with much safer systems today that feature multiple-point initiation. Specifications for U.S. nuclear weapons now require that a one-point detonation of the high-explosive system will have less than a one in a million chance of producing 4 pounds equivalent yield of trinitrotoluene (TNT), and weapons meeting this requirement are said to be "one-point safe." A nuclear weapon also may be designed to have an inherent one-point detonation self-destruct system. In other words, self-destruct systems have to be as safe as the primary detonators used to generate a full nuclear yield, making it unlikely that a self-destruct sequence will generate a nuclear yield. Friendly forces may use this self-destruct mechanism to deny the enemy use of a nuclear weapon or to prevent sabotage of the weapon.

The one-point safe design of U.S. nuclear weapons was tested in an accident on January 17, 1966, when a B-52 bomber collided with an air-refueling aircraft (a KC-135) over Palomares, Spain. The subsequent crash resulted in the one-point detonation of two nuclear weapons. Even though the one-point detonation of one of the weapons created a crater that was 20 feet in diameter, and approximately 1,400 tons of contaminated soil had to be removed from the area, there was no nuclear yield from either weapon.

By current Department of Energy standards, any newly designed nuclear weapon must be one-point safe. Given the moratorium on testing nuclear weapons, one-point detonation-related tests will have to be done using evolving three-dimensional computational capabilities.

—*Don Gillich*

See also: Broken Arrow; Surety

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ON-SITE INSPECTION AGENCY (OSIA)

The On-Site Inspection Agency (OSIA) is a U.S. Department of Defense organization under the control of the Defense Threat Reduction Agency. This joint-service agency is responsible for the verification of international nuclear and conventional arms control treaties and confidence-building agreements. OSIA accomplishes its mission by conducting inspections abroad, escorting foreign officials as they inspect U.S. facilities, and monitoring the truthfulness of foreign treaty-related assertions. The agency is in constant contact with international organizations responsible for the enforcement of nuclear arms reduction and control. OSIA personnel also coordinate closely with foreign counterparts to achieve treaty objectives.

The origins of the On-Site Inspection Agency can be traced to the Intermediate-Range Nuclear Forces (INF) Treaty of 1987, in which the United States and the Soviet Union agreed to destroy all intermediate-range nuclear missiles. One of the provisions of the treaty was for both parties to be able to verify the destruction of these weapons by the other side. OSIA was established on January 26, 1988, to conduct INF Treaty inspections. On February 1, 1988, U.S. Army Brigadier General Roland Lajoie became the first director of OSIA, with a staff of forty military and civilian personnel (*see* Intermediate-Range Nuclear Forces Treaty).

In preparation for an expanded role for OSIA pertaining to the Conventional Forces in Europe (CFE) Treaty, OSIA hired additional personnel. There were more than 600 OSIA staff members by 1992. The CFE Treaty was provisionally entered into force on July 17, 1992, and two days later, OSIA conducted its first baseline inspection in Russia.

In addition to carrying out INF and CFE treaty verification and monitoring provisions, OSIA has participated in a myriad of other missions. It has conducted monitoring for the Threshold Test Ban Treaty (1963); supported inspections for the United Nations Special Commission on Iraq (1991); assisted Operation Provide Hope, a humanitarian mission, in distributing food and medicines to former Soviet Union states (1992); and monitored compliance with the 1992 Open Skies Treaty and the Strategic Arms Reduction Treaties (START I and START II, 1991 and 1993). OSIA also provided support for peace efforts in Bosnia (*see* Open Skies Treaty; Strategic Arms Reduction Treaty; Strategic Arms Reduction Treaty; Threshold Test Ban Treaty).

OSIA is headquartered at Fort Belvoir, Virginia. Approximately 850 men and women from all four services as well as the Federal Civil Service are assigned to it, including inspectors, escorts, and linguists. The agency also manages the Defense Treaty Inspection Readiness Program (DTIRP), an outreach and educational program to prepare Department of Defense and U.S. contractor facilities for foreign inspections. OSIA has been assigned new duties in supporting operations in the global war on terrorism.

The On-Site Inspection Agency will continue to play an important role in the nation's security in the future. In addition to conducting managed access inspections of sensitive facilities in compliance with existing treaty verification regimes, it will likely be assigned new duties as new arms control treaties and agreements come into existence.

—Don Gillich

See also: Defense Threat Reduction Agency; Department of Defense; Verification

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OPEN SKIES TREATY

President Dwight D. Eisenhower first proposed a bilateral Open Skies initiative to the Soviet Union in 1955 but no formal agreement resulted for over thirty years. In 1989, President George H. W. Bush proposed a multilateral Open Skies agreement that was accepted by the nations of Europe. The treaty was designed to enhance military openness and transparency by providing each state party with the right to overfly the territory of any other signatories using an unarmed observation aircraft. The members of the North Atlantic Treaty Organization (NATO) and the former Warsaw Pact signed the treaty in Helsinki on March 24, 1992. The treaty was scheduled to enter into force sixty days after the last state deposited its instruments of ratification. It further allowed any state to accede to the agreement following entry into force of the treaty.

Following the demise of the Soviet Union, the governments of the Russian Federation, Belarus, Georgia, and Ukraine acknowledged their support for the agreement and submitted it for ratification by their respective parliaments. The United States ratified Open Skies in 1993, but the treaty languished in parliamentary committees in Belarus and Russia. These last two signatories finally ratified it in November 2001. The treaty entered into force on January 1, 2002. There are currently twenty-nine states parties to the treaty.

Open Skies is of unlimited duration, and all signatories must accept the overflights allowed under the treaty. The agreement covers the national territory of all signatories including territorial waters and islands. No portion may be excluded. The treaty has four primary objectives. First, it seeks to promote greater openness and transparency of military activities. Second, the treaty is designed to improve the monitoring of current and future arms control arrangements. Third, Open Skies is intended to strengthen the capacity of crisis prevention and crisis management. Finally, it provides aerial observation based on equity and effectiveness for all signatories.

Each participating state has the right to conduct, and the obligation to receive, flights over its territory based on an established quota. For example, the United States has a quota of forty-two overflights per year; however, during the initial four calendar years only thirty-one are permitted in any single year. Any signatory to the treaty may receive the results from an overflight. States are required to provide seventy-two hours' notice prior to commencing an overflight.

Open Skies observation aircraft are authorized to carry still and video cameras, infrared scanning devices, and side-looking radars. Since signing the agreement, many countries have developed Open Skies observation aircraft in accordance with treaty limitations. Numerous "practice flights" over the territory of participating states also have been conducted to insure all parties were fully prepared for implementation. By 2003, the United States had conducted more than ninety training flights over the territory of other nations and hosted thirty flights over U.S. territory.

—Jeffrey D. McCausland

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ORGANIZATION FOR SECURITY AND COOPERATION IN EUROPE (OSCE)

See Conference on Security and Cooperation in Europe (CSCE)

OUTER SPACE TREATY

The Outer Space Treaty of 1967 is the most important space-related arms control agreement to date. It has been described as the Magna Carta for space. The treaty channels human space activity onto peaceful paths and prohibits some types of military deployments. It extends international law into space and establishes the principle that space is to be free for exploration by all and used solely for peaceful purposes. The treaty also bans nuclear weapons and weapons of mass destruction in space. It laid a foundation for every major subsequent international space agreement: the 1968 Rescue and Return Agreement, the 1972 Liability Convention, and the 1975 Registration Convention. The treaty's vision for cooperative, noncommercial exploration and use of space was rooted in the Antarctic Treaty of 1959 and culminated in the (unratified) 1979 Moon Treaty, which emphasized that space is the common heritage of mankind. More than 125 states have signed or acceded to the Outer Space Treaty.

Even before the Soviet launch of Sputnik in 1957, both superpowers and the United Nations had become involved in structuring the legal regime for outer space. In the setting of the Cold War and the space race, some of the earliest space treaty initiatives seemed to be designed more for propaganda purposes than as serious negotiating positions. But by the early 1960s, more serious efforts emerged in the United Nations General Assembly (UNGA) and the Committee on the Peaceful Uses of Outer Space (COPUOS) that led to the adoption of UNGA Resolution 1721 in December 1961. UNGA 1721 was the first significant piece of space arms control and it established several foundational principles. It extended international law to outer space and celestial bodies, established that the exploration and use of space was to be free and open to all states, called for registration of all space launches, and sought cooperative agreements on international communication and meteorological space systems.

The John F. Kennedy administration intensified U.S. space arms control efforts, in part by relaxing verification standards, which helped lead to UNGA 1884 in October 1963 and UNGA 1962 in December 1963. These were the last two major UN space resolutions prior to the Outer Space Treaty, and they contained many of the most important provisions later codified in the treaty. UNGA Resolution 1962 declared that outer space was free for exploration by all and out of bounds to national sovereignty, that space activities were to be carried on for the benefit and in the interest of all humankind in accordance with the UN Charter and international law, and that states had to bear responsibility for all their national space activities, whether carried out by government or nongovernmental agencies. The resolution also stated that nations had to be guided by principles of cooperation and mutual assistance, with "appropriate international consultations" to precede any activity potentially harmful to peaceful uses of space, and that spacecraft were to remain under the jurisdiction of the launching state, with the latter accepting liability for any damage caused to foreign property by accidents. Astronauts, according to the General Assembly, were to be regarded as "envoys of mankind" and rendered every assistance in case of peril.

The Outer Space Treaty was negotiated at the UN during most of 1966 and was open for signature in January 1967. Many provisions of the treaty echo UNGA Resolutions 1884 and 1962. Several sections of the treaty also have direct military relevance. Article II indicates that "outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means." The most specific military prohibitions are found in Article IV:

> States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner. The moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military maneuvers on celestial bodies shall be forbidden. The use of military personnel for scientific research or for any other peaceful purpose shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the moon and other celestial bodies shall also not be prohibited. (Outer Space Treaty)

Although some analysts emphasize that the treaty only bans activities in which the superpowers had little interest anyway, the treaty certainly marked an important constraint on the development of ambitious military space capabilities during the Cold War. Foreclosing military options reduced incentives to consider space as the high ground in war. Perhaps most important, U.S. support for the unenforceable and nonverifiable prohibitions in the treaty—especially the possibility that nuclear weapons might be placed in space—signaled that U.S. officials viewed the interrelationships between space and national security in broad and holistic ways rather than in strictly military or strategic terms.

—Peter Hays

See also: Arms Control; Weapons of Mass Destruction

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OVERHEAD SURVEILLANCE

"Overhead surveillance" is a term used to describe a variety of space and aircraft systems that rely on different types of sensors to monitor developments on the ground.

Forward air controllers and unmanned aeries vehicles—small manned and unmanned aircraft that use a variety of sensors to monitor events on the ground—fly at relatively low altitudes and monitor events in limited areas. J-STARS aircraft (Joint Surveillance Target Attack Radar Systems) can search hundreds of miles of terrain, looking for moving tanks and low-flying aircraft. Rivet Joint aircraft (converted Boeing 707s) can monitor the radio airwaves, eavesdropping on the frequencies used by opposing militaries. At even higher altitudes, U-2 or unmanned Global Hawk aircraft, which operate at altitudes in excess of 60,000 feet, can gather signals and other types of photographic and electronic intelligence across an entire theater of operations. This information can be provided in real time to data-fusion centers to provide local commanders with a "god's-eye view" of the battlefield.

Satellites in orbit also can provide a variety of electronic signals and photographic intelligence. These national systems can be used to provide strategic intelligence to senior officials and to "cue" battlefield systems so that they can target areas of interest.

During the Cold War, overhead surveillance helped make arms control a reality by providing a nonintrusive way to verify compliance with arms control treaties. But because it can also be used to improve targeting against an opponent's arsenal, overhead surveillance can produce crisis instability if parties in a conflict lack a secure second-strike capability. Overhead surveillance is a key component of the transformation of the U.S. military and the emergence of a global precision-strike complex.

—*James J. Wirtz*

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P

PAKISTANI NUCLEAR WEAPONS PROGRAM

Pakistan tested a handful of nuclear weapons and declared itself a nuclear weapons state in May 1998. These tests brought to fruition a secret nuclear bomb production program that began soon after Indian troops defeated Pakistani forces in a 1971 war that saw Bangladesh (formerly East Pakistan) emerge as an independent state. Pakistan's initial motive for acquiring nuclear weapons was Prime Minister Zulfiqar Ali Bhutto's desire to have a way to ensure Pakistan's national security against an increasingly powerful adversary without having to rely on Western military assistance, which had proved to be unreliable. Especially after India tested its first nuclear explosive device in 1974, Bhutto and senior Pakistani military officials believed that nuclear weapons could help the Pakistan armed forces overcome the growing disparity in conventional military capabilities with India. Nuclear weapons also were attractive because they could be developed largely indigenously, with some financial support from Saudi Arabia and Libya and technical assistance from China and North Korea (the Koreans helped Pakistan build the Ghauri, Pakistan's first ballistic missile).

Pakistan initially attempted to acquire the facilities needed to produce weapons-grade plutonium. But when U.S. nonproliferation diplomacy blocked these efforts, Islamabad redirected its focus to produce gas-centrifuge machinery to en-

General Muhammad Aziz Khan, chairman of Pakistan's Joint Chiefs of Staff Committee, and other military personnel stand in front of Pakistan's short-range surface-to-surface ballistic missile HATF-III Ghaznavi before a test flight, October 2003. (ISPR/Handout/Reuters/Corbis) rich uranium for nuclear weapons. In 1976, Abdul Qadeer Khan, a Pakistani metallurgist working for the European nuclear consortium Urenco, managed to flee Europe with stolen centrifuge designs and a list of 100 companies that supplied centrifuge parts and materials. He soon set up a uranium enrichment plant at Kahuta, and by the mid-1980s he had navigated his way through the international export controls of the nuclear nonproliferation regime to produce enough bomb-grade material for a few nuclear weapons (*see* Enrichment; Plutonium; Uranium).

Sometime in the 1980s, Khan turned from recipient to supplier of nuclear technology. He was still bringing in material and components for Pakistan's nuclear bomb–making program, but he ordered more material than Pakistan needed. At the same time, Khan Research Laboratories (KRL) was maturing. KRL scientists published papers starting in 1987 on the construction of more difficult centrifuges made of maraging steel, rather than the earlier aluminum-based designs. Both trends—over-ordering and technological evolution—left Khan with excess inventory. During the 1990s, Khan became the world's most notorious nonstate exporter of nuclear material, selling nuclear technology, materials, and in at least one case, even bomb designs, to Iran, Libya, and North Korea.

Today Pakistan possesses stockpiles of nuclear weapon components and could assemble and deploy nuclear weapons within a few days to a week. Although Islamabad refuses to reveal information about the size, composition, and operational status of its nuclear arsenal, a rough estimate can be calculated from publicly available information. Assuming that Pakistan's Kahuta enrichment plant is able to produce between 80 and 140 kilograms of weapons-grade uranium per year, Pakistan could have between 900 and 1,370 kilograms of highly enriched uranium (HEU) available for weapons production. (The amount of HEU required for a bomb is believed to range between 12 and 25 kilograms, depending on the weapon design.) In addition, in 1998 Pakistan commissioned an unsafeguarded heavy-water research reactor at Khushab capable of yielding enough plutonium to make a few nuclear weapons annually. Combining these possible plutonium and HEU inventories, Pakistan could possess enough fissile material to fabricate between 37 and 100 weapons, with 65 as the median estimate found in the open literature (*see* Highly Enriched Uranium).

The Pakistan Air Force flies two kinds of aircraft that are probably capable of nuclear weapons delivery: U.S.-supplied F-16s and French Mirage 5 jets. After the United States suspended F-16 sales to Pakistan in 1990, however, Islamabad placed a high priority on acquiring ballistic missiles to offset India's conventional military superiority and to ensure reliable delivery of nuclear weapons. Liquid-fueled Ghauri missiles, developed with North Korean assistance, and solid-fueled Shaheen 1 and 2 missiles, developed with Chinese assistance, probably would be employed to deliver Pakistan's nuclear weapons.

—*Peter Lavoy*

See also: Strategic Forces

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PANTEX FACILITY, TEXAS

Pantex is the primary facility in the United States for dismantling and storing excess nuclear warheads, including those designated as part of America's strategic hedge. The facility is located near Amarillo, Texas. During the Cold War, it also manufactured the high-explosive components of nuclear weapons. Pantex and its 3,200 employees have been managed since 2001 by BWXT Pantex, a consortium company created by BWX Technologies, Honeywell, and Bechtel for the Department of Energy.

Pantex was established in 1942 as a U.S. Army ordnance plant for conventional ammunition. Closed following World War II, it was reopened in 1950 by the Atomic Energy Commission to provide an additional site for the development of high-explosive components of nuclear weapons. By the

1970s, the activities of several such plants around the country were consolidated at Pantex.

Many of the manufacturing processes at Pantex take place in self-contained buildings known as "Gravel Gerties." These were designed to collapse upon themselves in the event of an accidental explosion, thus minimizing the spread of radioactivity.

Since the end of the Cold War, the Pantex plant has remained busy dismantling excess warheads. It serves as the primary facility for storage of nuclear weapons components, including fissile triggers, and, since the closure of the Rocky Flats facility, plutonium pits. The "hedge force" of nondeployed nuclear weapons called for in the Nuclear Posture Review is also stored at Pantex.

—Jeffrey A. Larsen

See also: Fission Weapons; Hedge; Nuclear Posture Review; Pit; Rocky Flats, Colorado; Thermonuclear Bomb

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PARITY

No strategic issue generated greater controversy during the Cold War than the assessment of the balance of nuclear forces between the United States and the Soviet Union. After Washington lost its nuclear monopoly in 1949 and its overwhelming numerical superiority a decade later, Western strategists worried that the emergence of parity—the absence of a nuclear advantage on either side—might produce political and military gains for communism. These fears and the debates they generated produced two very different understandings of nuclear parity.

The minimalist concept of parity refers to a situation in which the weaker side has enough nuclear capability to inflict unacceptable damage on the stronger party. Moscow's deployment of long-range missiles in the late 1950s caused Americans to worry about their growing vulnerability to Soviet attack, but President Dwight D. Eisenhower calculated that an attack was unlikely because the Soviets were more vulnerable to U.S. nuclear strikes. Even when the disparity of vulnerability waned in the early 1970s, President Richard M. Nixon contended that the United States still could inflict a level of damage on a potential aggressor sufficient to deter him from attacking.

Hawkish critics pointed out that parity referred not to the possible destruction of population centers inherent in each side's nuclear arsenal, but rather to the balance of forces as a whole, and specifically to counterforce capacity. By this measure, Moscow had pulled equal to Washington in the late 1970s and was on its way to fielding a superior nuclear capability, which caused some analysts to warn that the Kremlin might try to initiate a disarming first nuclear strike or use its superiority to coerce Western governments. These contrasting strategic visions and definitions of parity were never reconciled and still inform strategic debates in the United States and elsewhere.

—Peter Lavoy

See also: Balance of Terror; Counterforce Targeting; Deterrence; Mutual Assured Destruction

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PAYLOAD

"Payload" is the term used to describe the amount of weight that can be carried to a specific range by a weapons delivery system or the type of weapon carried by a delivery system. Although the term can be used to describe the number of bombs or overall weight of bombs carried by an aircraft, it is most often used as a synonym for missile "throw weight."

Within certain limits, the amount of payload that a missile can deliver varies by range. Range can be extended by reducing payload, or higher payloads can be carried over shorter ranges. Payloads can include single-warhead reentry vehicles; multiple independently targetable reentry vehicles (MIRVs) loaded onto a MIRV bus; satellites; or special communication equipment. Payload limitations place a premium on the construction of "light" thermonuclear warheads that are relatively difficult to design and manufacture.

The United States and the Soviet Union have deployed missiles with the longest ranges and highest payloads of any produced in the five nuclear weapons states. The U.S. Peacekeeper MX intercontinental ballistic missile (ICBM) can carry a 3,950-

kilogram payload to a range of about 11,000 kilometers. The Soviet S-18 could carry an 8,000 kg payload to a range of about 10,000 km. The Chinese DF 31 ICBM that is currently under development will have a range of about 8,000 km and have a throw weight of about 700 kg.

Theater delivery systems have much shorter ranges and payloads. The SCUD-Bs that were once deployed by Iraq had a range of 300 km when carrying a 1,000 kg payload. The North Korean Nodong-1 has a 1,300-km range and a 750 kg payload. The Israeli Jericho-2 has a 1,500-km range and a 100 kg payload.

—James J. Wirtz

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PD-59

See United States Nuclear Forces and Doctrine

PEACEFUL COEXISTENCE

Peaceful coexistence is the maintenance of cordial and peaceful relations based on mutual understanding between parties who may hold conflicting views. It entered the Cold War vernacular in George Kennan's "Long Telegram" (February 1946). In this document, which he sent from his post in Moscow following a State Department request for suggestions on how to deal with an increasingly recalcitrant Soviet leadership, Kennan claimed that in the long term the Soviet Union and the United States could not exist in a state of permanent peaceful coexistence. As some aspects of the Cold War thawed in the late 1950s, however, the term did come to describe relations between the Soviet Union and the United States. Soviet leader Nikita Khrushchev saw peaceful coexistence as a continued absence of direct superpower confrontation, the resolution of disputes by negotiation, noninterference in internal affairs, and an increased amount of cooperation in economics, trade, science, and technology. This approach was epitomized by his trip to the United States in 1959 (*see* Cold War; Containment).

In the aftermath of the Cuban missile crisis, with mutual assured destruction a possibility, peaceful coexistence was spoken of as a clear alternative to nuclear Armageddon. From the Soviet point of view, peaceful coexistence did not prescribe any letup in the ideological struggle with the West, only a removal of the "hot war" option between the two superpowers. By the time of détente, peaceful coexistence was viewed by some in the West, notably by Henry Kissinger, as a tactical maneuver to gain time and consolidate Soviet economic and military potential.

Peaceful coexistence has also been used to describe the relationship between China and Taiwan since 1949 and is sometimes used to characterize the primary objective of the Roadmap for Peace in the Middle East (2003) between Israel and the Palestinians.

—J. Simon Rofe

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PEACEFUL NUCLEAR EXPLOSIONS

Peaceful nuclear explosions (PNEs) have been viewed at various times by the United States, the Soviet Union, and the People's Republic of China as a promising method to use in certain types of civilian projects that require the excavation of large amounts of earth.

From the 1950s until 1973, the United States detonated twenty-seven nuclear devices in Nevada, Alaska, New Mexico, Colorado, and other states as part of its "Plowshare" program. The tests were intended to determine the usefulness of nuclear explosions for the stimulation of oil and gas production and for other excavation projects. In the late 1950s and 1960s, U.S. officials considered excavating a new canal through the isthmus of Central America with nuclear explosives.

The largest excavation test experiment was conducted in 1962 at the Department of Energy's Nevada Test Site. This test, known as Sedan, displaced 12 million tons of earth, creating the largest manmade crater in the world. It also generated a large amount of fallout material that drifted beyond Nevada and over Utah. Explosions in oil and gas fields did stimulate production, but in some cases

Inspecting the crater created by the Project Sedan nuclear test explosion, Nevada Test Site, 1962. (Corbis)

they also made the fuel so radioactive that it could not be used. The Plowshare program was discontinued in 1973, after U.S. officials concluded that the negative aspects of PNEs (including criticism from the growing environmental movement) far outweighed their benefits.

The Soviet Union pursued a more vigorous PNE program. It began investigating the use of PNEs in the early 1960s and carried out a total of 124 PNEs by the late 1980s. The Soviet goals for PNEs included stimulating fossil-fuel production, blowing out oil and gas fires, creating underground cavities for storing fossil fuels, and disposing of toxic waste. With a technique called "seismic sounding," the Russians also created images of buried geologic formations by observing how they reflected shock waves produced by PNEs.

The first Soviet PNE detonations were conducted on October 25 and November 16, 1964. In January 1965, on the Semipalatinsk range, the Soviets carried out their first nuclear blasting operation for the purpose of excavation. They stopped their PNE program in 1988 as a result of Soviet leader Mikhail Gorbachev's disarmament initiatives.

In an effort to limit the yield of nuclear tests, the United States and the Soviet Union signed the Threshold Test Ban Treaty (TTBT) on July 3, 1974. The TTBT was negotiated under the assumption that it would be accompanied by a Peaceful Nuclear Explosions Treaty (PNET). The PNET was intended to allow a higher yield for PNEs conducted outside of weapons test sites specified under the TTBT. Because completing the PNET and negotiating its verification procedures turned out to be more challenging than concluding the TTBT, the Peaceful Nuclear Explosions Treaty was not signed until May 28, 1976. The PNET ended up setting the same upper yield limitation of 150 kilotons that had been agreed to in the TTBT. The PNET, however, allowed for several explosions to have an aggregate yield of up to 1.5 megatons (1,500 kilotons). The TTBT and the PNET did not enter into force until December

11, 1990, after the United States and the Soviet Union agreed on new verification protocols to the treaties (*see* Peaceful Nuclear Explosions Treaty; Threshold Test Ban Treaty).

Although China has never conducted a PNE, during the negotiations for the Comprehensive Test Ban Treaty (CTBT) China called for PNEs to be permitted under the CTBT regime. China's interest in PNEs may be the result of its interest in replicating the Soviet PNE program, or at least investigating the underlying reasons for Soviet interest in PNEs. A compromise was later reached, and the CTBT leaves open the possibility that PNEs could be allowed following a unanimous agreement to amend the treaty by signatories at a CTBT review conference to be held at regular intervals after the treaty's entry into force (*see* Comprehensive Test Ban Treaty).

—*Steven Rosenkrantz*

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PEACEFUL NUCLEAR EXPLOSIONS TREATY (PNET)

In the July 1974 Threshold Test Ban Treaty (TTBT), the United States and the Soviet Union recognized the need to negotiate an agreement to regulate underground nuclear explosions for peaceful purposes (also known as peaceful nuclear explosions, or PNEs). There is no essential distinction between the technology of a nuclear explosive device that would be used as a weapon and that of one used for a peaceful purpose, such as excavation or mining (*see* Peaceful Nuclear Explosions; Threshold Test Ban Treaty).

Negotiations on the PNE agreement began in Moscow on October 7, 1974, and culminated in the Treaty on Underground Nuclear Explosions for Peaceful Purposes, or the Peaceful Nuclear Explosions Treaty (PNET), signed in Washington and Moscow on May 28, 1976. The Treaty entered into force on December 11, 1990. The PNE agreement consists of the treaty, a detailed protocol to the treaty concluded in 1990, and an agreed statement describing activities that do not constitute a peaceful application as that term is used in the treaty.

The PNET governs all nuclear explosions carried out at locations outside the weapons test sites specified by the TTBT. Under the PNET, the United States and the Soviet Union agreed not to carry out any single nuclear explosions having a yield exceeding 150 kilotons, not to carry out any series of explosions (consisting of a number of individual explosions) having an aggregate yield exceeding 1,500 kilotons, and not to carry out any series of explosions having an aggregate yield exceeding 150 kilotons unless the individual explosions in the group could be identified and measured by agreed-upon verification procedures. The parties also reserved the right to carry out nuclear explosions for peaceful purposes in the territory of another country if requested to do so, but only in full compliance with the yield limitations and other provisions of the PNET and in accord with the Nuclear Nonproliferation Treaty (NPT).

Articles IV and V of the PNET set forth verification arrangements and authorize the use of national technical means. It states that information and access to sites of explosions will be provided by each side and includes a commitment not to interfere with verification means and procedures (*see* National Technical Means; Verification).

The protocol to the PNET identifies specific arrangements for ensuring that no weapons-related benefits precluded by the TTBT are derived by conducting a PNE. The statement that accompanies the treaty specifies that a "peaceful application" of an underground nuclear explosion would not include the developmental testing of a nuclear weapon. Such testing must be carried out at the nuclear weapons test sites specified by the terms of the TTBT and therefore is considered to be a nuclear weapon test.

The provisions of the PNET, together with those of the TTBT, established a comprehensive system of regulations to govern all underground nuclear explosions of the United States and the Soviet Union (and later, Russia). Both treaties have the same five-year duration, and neither party may withdraw from the PNET while the TTBT remains in force. Either party may withdraw from the PNET upon termination of the TTBT.

The PNET and the TTBT were both submitted to the U.S. Senate for its advice and consent on June 28, 1990. Following the Senate's approval of the treaties, the United States and the Soviet Union exchanged instruments of ratification. The treaties entered into force on December 11, 1990. A Joint Consultative Commission was created to discuss compliance questions, to develop further procedures for the on-site inspection process, and to facilitate cooperation in various areas.

If the Comprehensive Test Ban Treaty (CTBT) enters into force, both the TTBT and the PNET will be superseded, with all nuclear tests, including PNEs, prohibited. The CTBT does, however, leave open the possibility that PNEs could be allowed in the future. Article VIII provides that parties to a CTBT review conference, to be held ten years after the treaty's entry into force, could agree unanimously to amend the CTBT to permit PNEs (*see* Comprehensive Test Ban Treaty; Nuclear Test Ban).

—Steven Rosenkrantz

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PEACEKEEPER MISSILE

In the early 1970s, U.S. policymakers became concerned about the emergence of "heavy" Soviet intercontinental ballistic missiles (ICBMs) that could potentially carry up to a score of nuclear weapons. The first step in countering this ballistic missile threat was the construction of a heavy U.S. ICBM that also could carry many warheads. Peacekeeper was the U.S. Air Force name for the U.S. "missile experimental" (MX) intercontinental ballistic missile that would be developed as a counter to the Soviet SS-18 heavy ICBM. Peacekeeper was named after the famous six-shot revolver preferred by lawmen in the American West, the "gun that tamed the West," because of its supposed ability to quell Soviet ambitions once deployed (*see* Intercontinental Ballistic Missiles; Heavy ICBMs).

The MX was designed to carry up to fourteen multiple independently targetable reentry vehicles (MIRVs), but it was deployed with only ten warheads that gave the weapon a range of 8,100 miles. Research and development on the MX began in 1974, its first flight took place in June 1983, and it was deployed to F. E. Warren Air Force Base, Wyoming, in 1986. The Peacemaker has four stages. The first three stages use solid fuel and the last stage is liquid fueled. These four stages gave the MX greater range, payload, and accuracy than the Minuteman missile. As the end of the Cold War became apparent, production of the missile was capped at fifty missiles in 1990, curtailing the original plan to procure 100 Peacekeepers. In 2002, the United States began retiring Peacekeeper as part of its obligations under the Strategic Arms Reduction (START) treaties (*see* Accuracy; Minuteman ICBM; Strategic Arms Reduction Treaty; Strategic Arms Reduction Treaty).

MX is probably best remembered for the controversy it produced when it came to deciding how to base the missile. Because ICBMs were becoming increasingly vulnerable to attack as the number of accurate Soviet reentry vehicles increased, various plans were devised to create a "survivable" basing mode for the MX. The Jimmy Carter administration proposed a racetrack scheme in which the missile would be shuttled among many shelters in the American Southwest in a sort of shell game to frustrate Soviet efforts to target the missile. The Ronald Reagan administration initially developed a densepack plan whereby warhead fratricide would protect missiles in their shelters because the Soviets would not be able to destroy simultaneously all the missiles in densely clustered silos. Rail-garrison, a plan to deploy the MX on railroad cars that could be flushed onto the civilian railroad network in time of crisis, was the preferred deployment plan for MX as the Cold War came to an end, when further work on the Peacekeeper was more or less abandoned (*see* Dense Pack; Fratricide).

—Jeffrey A. Larsen

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PELINDABA, TREATY OF

See Nuclear Weapons Free Zones

PENETRATION AIDS

As work on missile defenses accelerated in the late 1950s, engineers developed a variety of deceptive techniques to fool defenses and ensure that offensive warheads could reach their targets. Based initially on technologies developed during World War II to spoof enemy radar, a variety of penetration aids have been developed. The most useful ones were perfected in the 1960s. These remain in widespread use on long-range missiles today and represent a fundamental challenge for successful missile defense.

Deployed on the same rocket stage as the actual warhead, most penetration aids (or "penaids") are released in space. They are intended to overwhelm defenses by reducing the ability of defensive radars to acquire or track actual attacking warheads. The most widely used types include inflatable decoys designed to resemble attacking warheads, dipole reflectors or chaff that reflect radar signals at the same wavelength as attacking warheads, active radar jamming systems, and radar signature-reducing (or stealth) coatings. Except for the last, all of these attempt to overcome defensive radars by making their operating frequencies useless or saturating defenses with the appearance of innumerable incoming warheads. They work exclusively during mid-course flight as warheads travel through space. Upon reentering the Earth's atmosphere, they burn up rapidly or otherwise begin to appear differently on tracking radar. Spoofing through reentry requires heavy decoys that mimic the flight characteristics of actual reentry vehicles. The latter require more missile payload, however, sharply reducing the number that can be carried, if any. Every full-size decoy that is carried means one less real warhead on that missile.

The first long-range missile capable of deploying penaids was the American Titan II intercontinental ballistic missile (ICBM), which became operational in 1963. The first Soviet missile to carry them reportedly was the R-36 (NATO designation: SS-9 Scarp), which became operational in 1966. Whether these weapons originally were equipped with penaids or acquired them in a subsequent modification is not clear in unclassified discussions. Most Soviet and American long-range missiles deployed since the mid-1960s are assumed to have been equipped with some sort of penaid. The United Kingdom created its own system in the 1970s, the Chevaline, an upgrade package for its U.S.-supplied Polaris submarine-launched ballistic missiles (SLBMs), which used both decoys and chaff. China also has penaid systems. Emerging missile powers should be expected to invest in penaids as well, including unintended varieties—such as rocket booster fragments—that confuse radar and guidance systems and complicate intercept solutions.

Overcoming penaids remains one of the most difficult problems of missile defense. The task depends largely on interpretive software to allocate radar resources, evaluate closely spaced objects, and discriminate the signature of actual warheads. As progress is made on this problem, states could adopt maneuvering reentry vehicles (MARVs) or even more exotic decoy systems to aid penetration by complicating interception fire control.

—*Aaron Karp*

See also: Countermeasures; Decoys; Missile Defense

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PERMISSIVE ACTION LINK (PAL)

A Permissive Action Link (PAL) is a device to prevent the unauthorized detonation of a nuclear weapon. The PAL system, originally designed by the United States, consists of a series of codes and mechanical devices that are either integrated into or attached to the nuclear weapon. Although utilized on some submarine-launched ballistic and cruise missiles, the PAL is most commonly linked to aircraft-delivered nuclear bombs, with the pilot or crew communicating with the PAL device from the cockpit. This differs from other delivery systems, such as land-based missile systems, which utilize elaborate procedures involving codes, mechanical keys, and participation by a crew to authorize launch and to arm the warhead.

PALs evolved during the 1950s as decision makers sought greater control over the developing nuclear force. Although the PAL design guards against unauthorized action by rogue U.S. military officers, a main concern was allied and enemy access. In the early days of the North Atlantic Treaty Organization (NATO), some U.S. nuclear weapons were at least partially controlled by allied countries. The PAL locks allow operators more freedom to disperse weapons while retaining ultimate negative control over their use. Certain PAL codes also can disable the weapon if a pilot or crew believes that it is about to fall into enemy hands. The PAL's electronic and cryptographic mechanisms can also sense attempts to bypass or override the PAL and will render the weapon inoperable.

PALs are classified as category A–F, in ascending order of sophistication. Although specific details of PAL construction and operation remain classified, it is known that the basic design lock contains electromechanical or solid-state electronics with six or twelve digits for code entry. One set of codes enables the system, or "unlocks" the PAL, while another set "authorizes" the functioning of the weapon. Early PALs were attached to the existing weapon's circuitry, but more modern PALs are "buried" within the weapon, making access more difficult. Additionally, on some PALs a limited-try feature disables the weapon if too many incorrect keys are entered.

—Chris Craige

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PERSHING II MISSILE

The Pershing II was an evolutionary improvement of the Pershing IA missile system that was fielded by the U.S. Army. Its performance and capabilities led the Soviets to fear it more than cruise missiles because of its short time of flight to targets in the western Soviet Union, its maneuvering reentry vehicle (MARV, designed to evade missile defenses), and its earth-penetrating nuclear warhead designed to destroy deeply buried command bunkers. It was deployed as part of the 1979 North Atlantic Treaty Organization (NATO) dual-track decision that matched intermediate-range nuclear force (INF) modernization with negotiations to remove these forces from Europe (*see* Dual-Track Decision; North Atlantic Treaty Organization).

The Pershing II, deployed to counter the Soviet SS-20, was perhaps the most political weapon to emerge in the nuclear age. As Soviet deployments of the triple-warhead SS-20 increased during the 1970s, NATO searched for ways of countering this Soviet threat. The Pershing II and the nuclear-tipped ground-launched cruise missile were selected to reaffirm the U.S. nuclear guarantee to NATO.

Equipped with an earth-penetrator warhead and a terminal guidance package in the nosecone that improved accuracy to feet instead of miles, the missile could reach Soviet command bunkers in Moscow 12 minutes after launch. Each Pershing II carried a single nuclear warhead. The system was deployed in Baden-Wurttemberg in southern West Germany, eventually reaching a complement of 108 launchers. The Pershing II was carried on an all-terrain wheeled trailer to allow for faster dispersal if placed on heightened alert.

The opposition to the Pershing II in West Germany was fierce, especially when the Soviets walked out of INF negotiations in Geneva over its deployment. The turmoil in Bonn was unprecedented. In one demonstration, 560,000 people protested the deployment of Pershing II. On November 22, 1983, however, the Bundestag approved the deployment, and the first missiles arrived the same day. NATO and the United States had won a political victory against the Soviet Union.

Soon after Pershing II was deployed, the Soviets returned to the negotiating table and agreed to eliminate all INF systems. The U.S. government, following the terms of the Intermediate-Range Nuclear Forces (INF) Treaty, destroyed all of its Pershing II missiles.

—Gilles Van Nederveen

See also: Intermediate-Range Nuclear Forces Treaty

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PHASED-ARRAY ANTENNA

Mechanically steered radar beams cannot establish the position of an object moving at a high rate of speed, such as a warhead reentering the atmosphere from outer space, because they lack sufficient receiver sensitivity and transmitter power. In the 1950s, U.S. engineers at the Massachusetts Institute of Technology working on the first antiballistic missile systems developed the phased-array radar to track high-speed objects. Soviet scientists developed a similar system, housed in massive arrays, to detect incoming missile warheads.

To make a very narrow beam with microwaves, an antenna must be very large, often stretching hundreds of feet in diameter. A physical dish antenna of that size would be awkward and slow to steer from one direction to another as it searched the sky for targets. A phased array is a lens of hundreds or thousands of small radar sets that emit microwaves so that the microwave peaks all line up in a specific direction. By changing the relative spacing of the peaks electronically, operators can steer the resulting narrow beam in any direction in a fraction of a second without causing any mechanical motion. Advances in solid-state electronics, especially fast phase shifters and computer technology for phase-array control, allowed these systems to mature.

Beam steering is accomplished by electronically controlling the timing, or phase, of the incoming and outgoing signals. A phased-array system can track while scanning because it has a large number of antenna elements that can carry out different tasks electronically independent of each other. The most impressive examples of phased-array radars are the ten-story-tall U.S. PAVE PAWS radars for submarine missile launch detection at Beale Air Force Base, California, and Cape Cod Air Force Station, Massachusetts; and the Ballistic Missile Early Warning Radar System (BMEWS) for intercontinental ballistic missile detection at Clear Air Force Station, Alaska; Thule, Greenland; and Fylingdale Moor, Great Britain.

—Gilles Van Nederveen

See also: Ballistic Missile Early Warning System; Early Warning; Missile Defense

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PIT

"Pit" is a slang term used to describe the "trigger" inside the physics package of a nuclear bomb. When scientists in the Manhattan Project developed an implosion device at Los Alamos, New Mexico, they used this term to describe the radioactive materials at the heart of the devices used in the Trinity device tested at White Sands and the "Fat Man" bomb dropped on Nagasaki, Japan. The term has since been used by the Department of Energy to identify the explosives and explosive material, from the detonators all the way into the core material that will be used for a fissile device, in both implosion devices and fusion-boosted fission devices. It is best to think of the "pit" of a nuclear device as being like a peach pit. It is the core of the device (*see* Fat Man; Implosion Devices; Manhattan Project; Nagasaki).

The term is used to differentiate the radioactive core of a nuclear weapon from the arming and power mechanisms that are part of the device. The specific composition of the pit varies from one type of device to another. In general terms, in an implosion device it is a ball-shaped piece of radioactive metal surrounded by conventional high explosives on the outer layer, with detonators spaced at specific intervals. This produces an even compression of the materials contained inside the pit and ensures simultaneous detonation of all explosive materials. A typical implosion-device pit consists of a core of radioactive material (such as uranium 235 [U-235] or plutonium 239 [Pu-239) encased in a shell (beryllium, for example) surrounded by high explosives (such as composition 4). The conventional explosion compresses the pit and creates a fission reaction in which an atom is split into two smaller fragments with a neutron. This method usually involves isotopes of uranium (U-235, U-233) or Pu-239. Nuclear fusion occurs when two smaller atoms are brought together (usually hydrogen or hydrogen isotopes such as deuterium or tritium) to form a larger atom (helium or helium isotopes). (*See* Deuterium; Isotopes; Plutonium; Tritium; Uranium.)

In weapons such as Fat Man, the plutonium would be at the core of the pit, and its casing would be manufactured to such tolerances that the explosive shell would uniformly compress the casing along with the plutonium inward to achieve a nuclear chain reaction, called a "critical mass." This compression creates a tamper effect and reflects neutrons back into the fissioning mass, making this type of device more efficient than other designs, such as the "Little Boy" gun-type device used in Hiroshima, Japan (*see* Criticality and Critical Mass; Gun-Type Devices; Hiroshima; Little Boy).

The pit is subject to decomposition over time owing to breakdown of both the fissile and explosive materials. Routine inspection is therefore required to ensure that the physics package remains functional. The only way to conduct the inspection is through disassembly in a controlled environment. In the United States this inspection routine is supervised by the Department of Energy.

Although the design of implosive nuclear weapons is sixty years old, refinements in materials and design have resulted in weapons of increasing yield using fewer materials. Improved technology has resulted in a gradual reduction in size of nuclear weapons from the 5-ton Fat Man to man-portable weapons that have three times the yield. Future designs of the pit will be greatly dependent on supercomputer modeling and subcritical testing due to current restrictions on nuclear arms tests.

—Dan Goodrich

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PLUTONIUM

Plutonium (Pu) is a manmade radioactive element, the ninety-fourth in the periodic table. Its radioactivity, toxicity, and explosive yield have made it one of the most feared elements in history. Plutonium is a by-product of the fission process that takes place in nuclear reactors and results from neutron capture by uranium 238 (U-238), in particular. The separation and extraction process consumes large amounts of energy. All plutonium isotopes are radioactive. The most important is plutonium 239 (Pu-239) because it is fissionable, has a long half-life (24,360 years), and can be readily produced in large quantities in breeder reactors by neutron irradiation of plentiful but nonfissile U-238. The metal has a silvery appearance and takes on a yellow tarnish when exposed to air. It is chemically reactive. A relatively large piece of plutonium is warm to the touch because of the energy given off in alpha decay (*see* Half-Life; Isotopes; Neutrons; Nuclear Fuel Cycle; Reactor Operations; Uranium).

Critical mass (the amount that will spontaneously explode when brought together) becomes a safety consideration when handling quantities of plutonium in excess of 300 grams. The critical mass of Pu-239 is only about one-third that of U-235, hence its utility in weapons design. The element was first detected in 1940 as the isotope Pu-238 by Glenn Seaborg, Joseph Kennedy, and Arthur Wahl, who produced it by deuteron bombardment of U-238 at Berkeley, California (*see* Criticality and Critical Mass).

Pu-238, Pu-240, and Pu-242 emit neutrons as their nuclei spontaneously fission. They also decay, and the decay heat of Pu-238 enables it to be used as an electricity source in the radioisotope thermoelectric generators (RTG) of some cardiac pacemakers, space satellites, and navigation beacons. Plutonium is toxic in a chemical sense and its ionizing radiation also makes it a radiation hazard. The main threat to humans from plutonium comes from inhalation. Although it is very difficult to create airborne dispersion of a heavy metal, in the case of plutonium particles the size of 10 microns or less are a hazard because they can be taken into the lungs. The alpha particles have a high rate of emission, and the element is absorbed on bone surfaces and collected in the liver; thus, plutonium and other transuranium elements are radiological poisons and must be handled with very special equipment and precautions. Plutonium in liquid solution is more likely to become critical than solid plutonium.

Plutonium is also a fire hazard, especially finely divided material. Its chemical reaction with oxygen and water may result in an accumulation of plutonium hydride, a pyrophoric compound (that is, a material that will burn in air at room temperature). Plutonium expands considerably in size as it oxidizes and thus may break its shipping container if oxidation begins. Magnesium oxide sand is the most effective material for extinguishing a plutonium fire. It both cools the burning material, acting as a heat sink, and blocks oxygen flow to the fire.

The production of plutonium is carried out in two industrial stages. The first involves the irradiation of uranium fuel rods by neutrons in nuclear reactors. The second involves the chemical separation of plutonium from the uranium, transuranic elements, and from fission products contained in discharges or irradiated fuel. These techniques are usually referred to as "reprocessing" when applied commercially and "plutonium separation" when undertaken to recover material to be used in nuclear weapons. The nuclear weapons producers have obtained optimal isotopic content of plutonium mainly by controlling the extent to which uranium fuel elements are bombarded with neutrons in nuclear reactors.

It takes about 10 kilograms of nearly pure Pu-239 to make a bomb. Producing this amount would require 30 megawatt-years of reactor operation, with frequent fuel changes and reprocessing of hot fuel rods. Plutonium is a key component in nuclear weapons. Care has to be taken to avoid accumulation of amounts of plutonium that approach critical mass—the amount of plutonium that will self-generate a nuclear reaction. For weapons use, Pu-240 is considered a serious contaminant, and it is not feasible to separate Pu-240 from Pu-239.

The Trinity test on July 16, 1945, used about 6 kilograms of plutonium to achieve the world's first nuclear explosion. Fat Man, dropped on Nagasaki, Japan, on August 9, 1945, used 6.2 kilograms of plutonium. Plutonium for the weapons were made at Hanford, Washington, and Savannah River, South Carolina. The fuel rods for these reactors were produced in gaseous-diffusion plants. After the fuel was irradiated in the reactor, it was sent for reprocessing to the plutonium-uranium extraction plant (the PUREX Plant). (*See* Hanford, Washington; Oak Ridge National Laboratory; Savannah River Site; Trinity Site.)

During reprocessing, plutonium is separated from spent nuclear fuel rods. Reprocessing plants handle spent fuel mechanically and chemically to extract plutonium from uranium and other fission products in the burnt fuel rods. Plutonium separation occurs in three main stages. In the first, the spent fuel assemblies are dismantled and the fuel rods are chopped into short segments, after the cladding on the fuel rods has been removed mechanically. In the second stage, the extracted fuel is dissolved in hot nitric acid. In the third and most complex stage, the plutonium and uranium are separated from other products in the fuel rods, such as actinides and fission products, and then from each other, through a technique known as "solvent extraction." The plutonium and uranium are usually passed through several solvent-extraction cycles to remove other impurities and reach the required levels of purity.

During the Cold War, the Z plant, or plutonium finishing plant at the Hanford nuclear complex, converted liquid plutonium nitrate from the PUREX Plant into solid, disc-shaped metal buttons the size of hockey pucks. The machined plutonium was then shipped to the Rocky Flats Plant, Colorado, to be turned into nuclear weapon components. Since the end of the Cold War, the United States and Russia have been converting some of their excess plutonium stockpiles to mixed oxide fuel, where uranium and plutonium are blended so that they can be burned in commercial electrical power reactors. The Rocky Flats plant has been closed, and the only remaining plutonium manufacturing facility in the United States is located at Los Alamos National Laboratory, New Mexico (*see* Rocky Flats, Colorado).

—*Gilles Van Nederveen*

See also: Mixed Oxide Fuel; Reprocessing

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POLARIS SLBMS/SSBNS

Polaris, named after the North Star, was a two-stage ballistic missile powered by solid-fuel rocket motors and controlled by a self-contained inertial guidance system. It was designed to be launched from a submerged submarine. On July 20, 1960, Polaris became the first ballistic missile to be launched from a submarine under water. (In 1942, Germany had successfully test-fired mortar rounds from partially submerged mortar tubes, but no missile had ever been launched from a submerged submarine.) A second A1 Polaris missile was fired three hours later, demonstrating that multiple wartime missile launches were feasible. The Polaris program was the culmination of an intensive four-year program by the Department of the Navy.

There were three versions of the Polaris, designated A1, A2, and A3. Each modification of the missile improved its range, accuracy, target flexibility, and throw weight. Polaris was launched from three classes of fleet ballistic missile nuclear-propelled submarines (SSBNs): the George Washington class, the Ethan Allen class, and the Lafayette class.

The first Polaris A2 launch occurred on October 23, 1961, and the first Polaris A3 launch took place on October 26, 1963. Polaris A1 had an initial range of 1,200 nautical miles, and the A2 missile had a range of 1,500 nautical miles. Polaris A1 and A2 carried a single nuclear warhead, and the Polaris A3 carried multiple but not independently targetable warheads. On May 6, 1962, a nuclear-armed Polaris A1 was launched from the USS *Ethan Allen* while submerged in the Pacific, and its nuclear warhead was detonated over the South Pacific on target. This 1962 launch and nuclear weapon detonation remains the only complete proof test of a U.S. strategic missile ever conducted. The A2 missile became operational in 1962 when it was first deployed on the USS *Ethan Allen.* The A1 missile was retired in 1965, and the A2 was retired from service in 1974.

The Polaris A3 represented a significantly greater technological advance over Polaris A2, and with an approximately 85 percent new design, it was practically an entirely new missile. With a range of 2,500 nautical miles, it had the ability to reach any land target on the Earth. It also was the only Polaris missile to be equipped with multiple (three) reentry bodies, which were initially intended to serve as a way to penetrate primitive Soviet missile defenses. The first flight test of the A3 was conducted in August 1962, and the A3 became operational in September 1964 when the USS *Daniel Webster* began its initial operational patrol with sixteen A3s aboard. All Polaris A3 missiles were retired by the U.S. Navy when the last U.S. Polaris SSBN offloaded in February 1982.

The term "Polaris" also is used to describe the submarine on which the Polaris ballistic missiles were deployed. The Polaris submarine was 380 feet long with a 33-foot beam and weighed 6,700 tons. It was designated the 598 class and later the 608 class. There were five submarines in each class. The last Polaris A3 SSBN was reclassified as a nonstrategic submarine and eventually retired from service in 1983.

—*Guy Roberts*

See also: Poseidon SLBMs/SSBNs; Submarines, Nuclear-Powered Ballistic Missiles

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PORTSMOUTH ENRICHMENT FACILITY

The Portsmouth gaseous-diffusion facility located near Piketon, Ohio, was the United States' primary plant during the Cold War for the production of highly enriched uranium (HEU). It had a sister facility located in Paducah, Kentucky, which produced low enriched uranium that was fed to the Portsmouth facility for increased enrichment to HEU levels greater than 90 percent. Earlier gaseous-diffusion facilities were operated at Oak Ridge, Tennessee (*see* Highly Enriched Uranium; Low Enriched Uranium; Oak Ridge National Laboratory).

The Portsmouth facility housed 4,080 gaseous-diffusion cascades in three buildings constructed in the mid-1950s. This technique for producing HEU, while proven, was extremely expensive because it required a large amount of electricity. A new technology using gas centrifuges was chosen by the Department of Energy in the 1980s to replace gaseous diffusion, and a new plant was begun at Portsmouth to house this process. It was scheduled for completion in 1994 but canceled in 1985.

The Portsmouth facility was only running at 25 percent of its capacity in the 1990s. It was privatized in 1998 by the U.S. Enrichment Corporation (USEC). It was closed completely (put in a "cold standby" status) in June 2001 because of its high energy costs, a global glut of enriched uranium, and excess U.S. capacity to produce HEU (the Paducah plant was kept open by the USEC to produce reactor fuel). Environmental cleanup efforts at Portsmouth will last for decades.

In early 2004, USEC chose Piketon, Ohio, for a new facility to test the centrifuge method of uranium enrichment. It plans to start testing in 2005, using the mothballed gas centrifuges left on site after the aborted 1980s effort to shift to centrifuge enrichment. It will then use the facility (called the American Centrifuge Demonstration Facility) to help gain financing for a full-scale, commercial centrifuge plant, which it aims to bring on line in 2010.

—Jeffrey A. Larsen

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POSEIDON SLBMS/SSBNS

The Poseidon submarine-launched ballistic missile, the follow-on system to the Polaris program, was a two-stage, solid-propellant missile designed to be launched from a submerged fleet ballistic missile (FBM) submarine. It was 2 feet longer than the 32-foot Polaris A3 missile but had a much larger diameter (74 versus 54 inches) and was 30,000 pounds heavier. Despite the increase in size of the Poseidon missile, the growth potential of the FBM submarines allowed Poseidon missiles to fit into the same sixteen missile launch tubes that had earlier carried Polaris missiles. The Poseidon C3 missile was a substantial improvement over Polaris. It provided a greater payload capacity and was capable of delivering multiple warheads, widely spaced, on separate targets over a variety of target footprints. This capability of using multiple independently targetable reentry vehicles (MIRVs) enabled Poseidon to cover a wide range and hold at risk a greater number of targets with nuclear weapons.

The Poseidon C3 missile had a range of 2,500 nautical miles and was the first submarine ballistic missile to be capable of targeting a number of different targets located within the "footprint" of the missile (the area in which individual warheads can be delivered by a single missile). Each 64,000-pound Poseidon C3 could carry up to fourteen Mark 3 reentry bodies. These could be targeted to maximize damage against a single target or targeted against fourteen individual targets. It was also possible to extend the range of the Poseidon by offloading warheads or penetration aids (devices intended to complicate any efforts at missile defense from the payload. Apart from the much-increased size and weight, Poseidon's main advantage over the Polaris A3 missile was its ability to deliver a warhead to multiple targets. Poseidon C3 also incorporated substantial improvements over Polaris in accuracy and resistance to countermeasures.

The Poseidon missile was deployed initially on thirty-one of the U.S. Navy's forty-one FBM submarines. The first ten fleet ballistic missile submarines to be built, including five in the George Washington class and five in the Ethan Allen class, were not retrofitted to carry Poseidon. The first launching of a Poseidon missile from a submerged submarine occurred on August 3, 1970, from the USS *James Madison* (SSBN 627) off the coast of Florida near Cape Canaveral. The Poseidon C3 became operational on March 31, 1971, when the USS *James Madison* began its initial operational patrol carrying sixteen Poseidon C3 missiles.

In addition to being deployed on Polaris submarines, Poseidon C3 missiles were deployed on submarines, also named Poseidon, that were specially converted to accommodate the larger and heavier missile. In 1970, four SSBN-627 class submarines were converted to carry the Poseidon C3 missile. Although some Polaris submarines were later converted to carry Poseidon, the new Poseidon submarines, at 425 feet long, were much larger than the submarines designed to carry the Polaris missile. They had the same beam width (33 feet) and displaced 8,250 tons (versus 6,700 tons for Polaris). In the 1980s, of the thirty-one Poseidon FBM submarines, twelve were later backfitted to carry the Trident I (C4) missile. The last Poseidon SSBN offloaded its Poseidon C3 missiles and was retired from service in September 1992 (*see* Polaris SSBNs/SLBMs).

—*Guy Roberts*

See also: Submarines, Nuclear-Powered Ballistic Missiles

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POST-ATTACK COMMAND AND CONTROL SYSTEM (PACCS)

Fearing a Soviet nuclear surprise attack, the U.S. Strategic Air Command (SAC) began modifying KC-135A tankers to serve as airborne command posts in 1957. Pleased with initial tests, officials continued the program, and the fleet soon grew to fifteen EC-135 aircraft. These aircraft, code-named "Looking Glass," carried a general officer who could take command of nuclear forces in the event SAC's underground command post at Offutt Air Force Base (AFB), Nebraska, was destroyed. Between February 1961 and July 1990, a Looking Glass EC-135 was on continuous airborne alert over the United States. Other EC-135s were assigned to the numbered air forces at Westover AFB, Massachusetts; Barksdale AFB, Louisiana; and March AFB, California. In the 1960s, as fears grew about a submarine-launched surprise attack on U.S. coastal areas, additional bases acquired air command posts. The number of command posts grew as nuclear warfighting commanders were given their own EC-135s, which were deployed at Langley AFB, Virginia (Atlantic Command); Hickam AFB, Hawaii (Pacific Command); and Mildenhall AFB, UK (European Command). Together, these posts formed the Post-Attack Command and Control System (PACCS).

To tie the National Emergency Airborne Command Post (NEACP) aircraft to Looking Glass and other airborne command posts, officials assigned special radio-relay aircraft to Ellsworth AFB, South Dakota, and Grissom AFB, Indiana. Soviet SS-9 intercontinental ballistic missile (ICBM) deployments, which gave the Soviet Union the ability to strike Minuteman launch control centers, prompted SAC planners to add airborne launch control center (ALCC) equipment to some EC-135s, giving them the capability to launch the land-based U.S. ICBM force. Based around an EC-135C Looking Glass operating from Offutt, auxiliary command posts stood 15-minute ground alert at Offutt and Minot AFB, North Dakota. Three ALCCs also stood alert at Minot, and two radio aircraft were located at Grissom and Rickenbacker AFB, Ohio.

In the event of an emergency, Looking Glass and the two auxiliary command posts would fly over the central United States, the three ALCCs would fly above the Minuteman missile fields in the north central and northwestern United States, and the two radio-relay aircraft would fly over the Midwest, establishing and maintaining communications links with the NEACP airborne over the East Coast of the United States.

Looking Glass aircraft carried out an airborne alert for decades, flying over the Midwest day and night to preserve positive nuclear command and control in the event of a surprise Soviet nuclear attack. Looking Glass personnel also would communicate with the U.S. Navy's EC-130 "take charge and move out" (TACMO) aircraft airborne over the Atlantic and Pacific oceans to guarantee that the U.S. Fleet Ballistic Missile Submarine force on their patrol stations could receive Emergency Action Messages ordering them to execute their missions in the event of nuclear war. In 1998, as strategic forces in the United States were realigned, the Air Force command posts were retired and the Looking Glass and ALCC missions were transferred to the U.S. Navy's E-6B TACMO aircraft based at Tinker AFB, Oklahoma, and forward deployed to Offutt and other U.S. locations.

—*Gilles Van Nederveen*

See also: Command and Control; National Emergency Airborne Command Post

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POUNDS PER SQUARE INCH
See Silo Basing

PREEMPTIVE ATTACK
A preemptive attack is one undertaken based on clear and convincing evidence that an opponent is about to attack. It is often used interchangeably and incorrectly with the term "preventive war," which denotes a situation in which policymakers believe war is inevitable, but not imminent. A preemptive attack is premised on a right recognized under customary international law that a state has the legal right and obligation to respond to an imminent danger to its national security. National officials do not and should not have to wait until physically attacked to respond, especially when that attack is self-evidently imminent. The right to a preemptive attack is often couched in terms of anticipatory self-defense, although states that launch a preemptive attack shoulder the moral and political burden of convincing an international audience that an attack against their interests was about to be launched.

Secretary of State Daniel Webster in the famous Caroline Case of 1842 articulated this right of preemptive response or anticipatory self-defense. He stated that the right of preemptive attack was restricted to those cases where the necessity "is instant, overwhelming, and leaving no choice of means, and no moment for deliberation." He further argued that the act should involve "nothing unreasonable or excessive, since the act justified by the necessity of self-defense must be limited by that necessity and clearly within it" (D'Amato, p. 32). Webster's criteria are internationally accepted as the basis for determining the legitimacy of a preemptive attack.

As with preventive attacks, necessity is the most important precondition to the legitimate use of military force. The initial determination of necessity is made by the target state based on a number of facts. These include, but are not limited to, the nature of the coercion being applied, the relative size and power of the aggressor state, the nature of the aggressor's objectives, and the consequence if those objectives are achieved. One example of a preemptive attack is the Israeli preemptive strike on Egyptian, Jordanian, and Syrian forces as they massed against Israel, which precipitated the 1967 war.

—*Guy Roberts*

See also: Preventive War; Reciprocal Fear of Surprise Attack

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PRESIDENTIAL NUCLEAR INITIATIVES
The Presidential Nuclear Initiatives (PNIs) of 1991 and 1992 were a set of unilateral declarations by U.S. president George H. W. Bush and Soviet leader Mikhail Gorbachev (and later Russian President Boris Yeltsin). In these initiatives, they pledged significant steps to lessen the dangers associated with large stockpiles of nuclear weapons. The PNIs laid out plans to withdraw and eliminate some of the most dangerous weapons—tactical nuclear weapons (TNWs)—and to take measures that would reduce the alert levels and increase the physical security of the remaining nuclear weapons, thus making nuclear war less likely and reducing the danger of proliferation. The result of these unilateral declarations was that, for the first time in history, the United States and the Soviet Union pledged to withdraw and destroy a significant portion of their large nuclear arsenals without a treaty.

In 1991, the impending breakup of the Soviet Union and a coup attempt against Gorbachev highlighted the risks that instability posed to the security of the massive Soviet nuclear arsenal, which was spread across many of the Soviet republics. In September, Bush gave an address to the nation on the reduction of U.S. and Soviet nuclear stockpiles. He announced unilateral reductions in U.S. tactical nuclear weapons—a category that had been left out of earlier treaties—calling upon Gorbachev to reciprocate. The United States announced plans to eliminate its short-range nuclear missile warheads, nuclear artillery shells, and nuclear depth charges. It promised to withdraw other naval TNWs and place them in storage, leaving only tactical bombs—part of the U.S. commitment to NATO—unaffected. Bush also canceled the only U.S. TNW in development, showing the U.S. intent to maintain these reductions.

In addition, Bush called for the rapid ratification of the Strategic Arms Reduction Treaty (START I, 1991), which had been signed in July, to mandate nuclear weapons reductions and to implement a regime that would verify these moves. He announced that all U.S. bombers would stand down from their alert status immediately and that U.S. intercontinental ballistic missiles (ICBMs) would be removed from their alert posture as soon as START was ratified. Two new nuclear weapons programs were canceled, and an agreement to eliminate missiles with multiple independently targetable reentry vehicles (MIRVs) was encouraged (*see* Strategic Arms Reduction Treaty; Multiple Independently Targetable Reentry Vehicle).

President Bush claimed that the United States and the Soviet Union no longer needed such large nuclear arsenals and that these changes would increase the stability and security of the U.S. and Soviet arsenals. In addition, a reduction in the number of nuclear weapons—especially of smaller TNWs that could be more easily stolen or diverted—made nuclear proliferation, and therefore the chance that terrorists could acquire nuclear weapons, less likely. Thus, President Bush suggested cooperation on measures to increase the safety and stability of the remainder of the Cold War arsenals, to ensure that the weapons would be safely transported and stored as they awaited dismantlement, and to maintain sufficient command and control structures to prevent unauthorized or accidental launch.

Eight days after the U.S. initiative was announced, Gorbachev responded, stating that the Soviet Union would destroy its short-range nuclear missile warheads, nuclear artillery shells, and nuclear land mines. The Soviets would withdraw their naval and land-based nuclear air defense weapons and either destroy them or put them in storage. Gorbachev also announced the withdrawal of TNWs from the four other former Soviet republics, a move that was completed in 1992.

Bush responded to Gorbachev's announcement by declaring that the United States would withdraw all of its nuclear weapons from South Korea and reduce the number of tactical bombs in Europe by half. By 1998, only seven years after the PNIs were first announced, the United States had reduced the number of its tactical bombs in Europe by some 90 percent. Russia pledged to eliminate nearly 14,000 of the more than 21,000 TNWs that the Soviet Union possessed at the time the initiatives were announced, although whether Russia has carried out these promised reductions is unclear.

After the dissolution of the Soviet Union at the end of 1991, Boris Yeltsin became the first president of the Russian Federation. Yeltsin reaffirmed Gorbachev's pledges and pressed for further reductions. He announced that half of the TNWs in the Russian Air Force, along with one-third of Russian naval TNWs and one-half of Russian air defense weapons, would be destroyed by the year 2000. He also stated that production of two types of heavy bombers would cease and that 1,250 nuclear warheads had been taken off of high-alert status, reducing the likelihood that they would be launched accidentally. He proposed deep cuts in the U.S. and Russian strategic arsenals. Although the United States did not respond to many of the measures Yeltsin proposed, the groundwork was laid for a more stable nuclear environment.

The Presidential Nuclear Initiatives reflected the changing nature of the nuclear threat after the end of the Cold War. As the Soviet Union collapsed, it became unlikely that a Soviet invasion of Europe—which U.S. tactical nuclear weapons were built to counter—would occur. The massive U.S. and Russian strategic nuclear arsenals were thought to be a strong enough deterrent against nuclear war. The largest threat perceived by analysts in the post–Cold War world was that "loose" nukes from the crumbling Soviet empire would make it into the hands of rogue states or terrorists. Because of the PNIs, the post–Cold War period started off with confidence-building measures that helped to reduce tensions and eliminate the threat posed by the smallest and most portable nuclear weapons.

—*Andrea Gabbitas*

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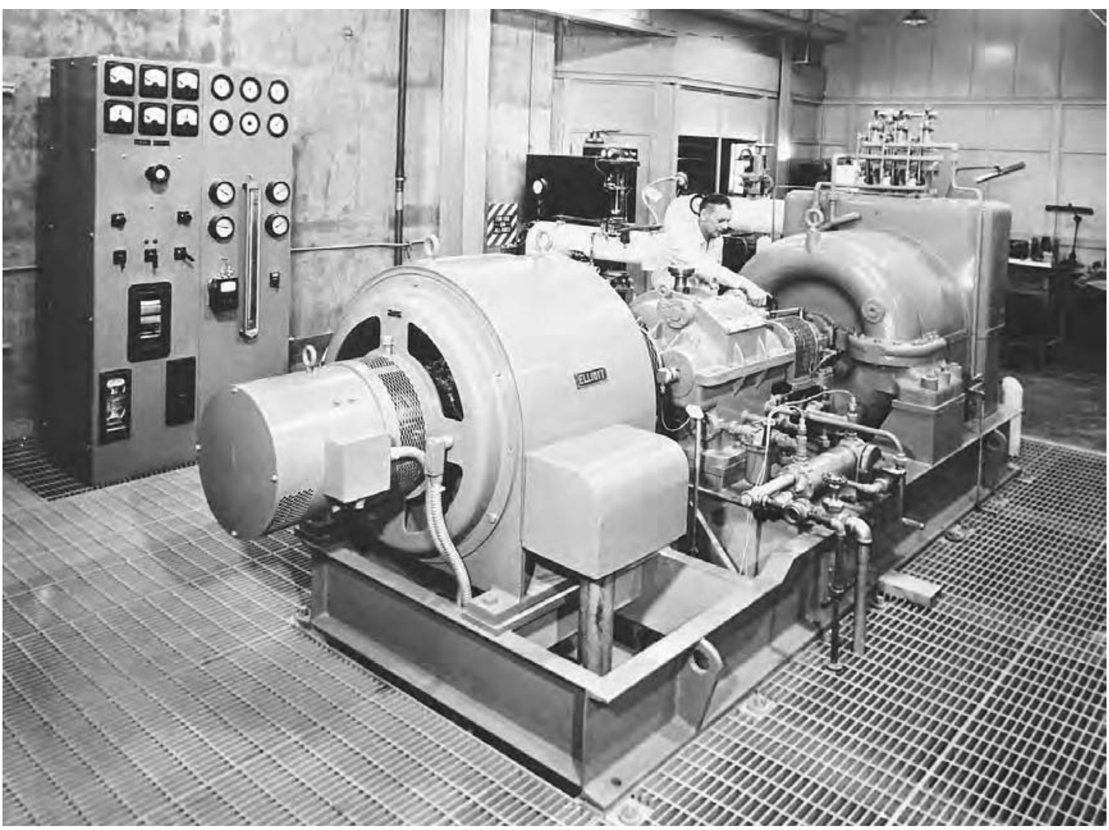
PRESSURIZED-WATER REACTORS (PWRs)

One of the most widely used nuclear reactor types in the world today (along with the boiling-water reactor, or BWR), the pressurized-water reactor (PWR) was one of the first types of power reactors developed in the United States for the commercial production of electricity. Both BWRs and PWRs are called "light-water reactors" because light water (H_2O) typically flows through the core to act as a coolant, reflector, and moderator. In a PWR, this water is pressurized to approximately 2,250 pounds per square inch to prevent the water from boiling.

PWRs were originally designed as the power plant for ships of the U.S. Navy, and then adapted for use in the commercial power industry. The first nuclear-powered submarine, the USS *Nautilus,* put to sea in 1955 equipped with a PWR.

Commercial PWRs generally operate with slightly enriched uranium as the fuel (that is, with a higher concentration of uranium 235 than found in nature—typically 2 to 5 percent, compared to 0.72 percent in nature.) The pressurized water flowing through the core is heated by the energy released in the fission of the fuel and then flows through a heat



The first useful electricity from atomic energy was produced by the Pressurized Water Reactor in the foreground, operating on heat from the Experimental Breeder Reactor at the Nuclear Reactor Testing Station, Arco, Idaho, 1951. (Bettmann/Corbis) exchanger. The heat is exchanged to a secondary fluid, generally water, that is not pressurized and so turns to steam. The steam drives a turbine that powers a generator, producing electricity.

The next generation of nuclear reactors will seek to enhance the economic competitiveness of commercial nuclear power. New modular designs will utilize simple technology to improve resistance to proliferation and enhance safety.

—*Brian Moretti*

See also: Light-Water Reactors; Reactor Operations; Uranium

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PREVENTIVE WAR

A preventive war is one that occurs when national leaders believe that war is inevitable and that it is better to initiate hostilities rather than letting the opponent attack when the situation is favorable for them. It reflects the political judgment that diplomacy or other measures short of war would not be sufficient to eliminate an increasingly acute security threat. Preventive war is different from preemption because the threat is not imminent; that is, it occurs in the absence of clear indications that the opponent is about to strike. A preventive attack is premised on a state's fundamental right, recognized under the UN Charter (Article 51), to respond to threats to its national security, although the general thrust of the United Nations is to resolve international disputes without resorting to violence.

One recent type of threat, the development of weapons of mass destruction, has prompted some states to launch preventive attacks and war. The 1981 Israeli attack on the Iraqi nuclear reactor at Osirik, for example, was intended to cripple Saddam Hussein's quest to obtain nuclear weapons. The Israelis never claimed Iraq had a nuclear weapon, only that the reactor was a key part of Iraq's clandestine nuclear weapons program and that if Israel waited it would not be able to effectively interrupt the program's progress. Similarly, in the spring of 2003, the United States launched a preventive war against Iraq to eliminate the threat that Iraq would develop, use, or transfer weapons of mass destruction to terrorist organizations.

Given the emerging international norm against preventive war, those advocating preventive war as national policy, regardless of the perception of dire threat, shoulder an enormous political and moral burden to justify their policies. Some would argue, however, that no war should ever be considered inevitable and that preventive war is simply a euphemism for aggression.

—*Guy Roberts*

See also: Preemptive Attack

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PRIMARY STAGE

The primary stage of a thermonuclear warhead is a fission device that creates the necessary conditions for a subsequent fusion reaction. Modern thermonuclear warheads use both fission and fusion reactions, traditionally referred to as the primary and secondary stages, to generate a desired explosive force.

When the warhead is detonated, chemical explosives compress the primary stage, which is often composed of plutonium 239. Because of the high temperatures and pressures generated by the chemical explosives, the plutonium begins to split into new types of atoms. These new atoms have a collective weight less than the weight of their original components; the remaining mass is released as a tremendous amount of energy and neutrons. The energy is what makes up the power of an atomic blast, and the additional neutrons perpetuate the fission chain reaction (*see* Neutrons).

In modern thermonuclear warheads, this primary mechanism is surrounded by a layer of lithium deuteride (the isotope of hydrogen with a mass number of two; see Isotopes), which is in turn encased in a thick outer layer known as the "tamper," which is often composed of fissionable material and functions to hold the contents together to contain the pressure and heat needed to generate a fusion explosion. Neutrons from the atomic explosion cause the lithium to fission into helium and tritium (the isotope of hydrogen with the mass number three), which yields a tremendous amount of energy.

The primary stage generates the conditions required for fusion, raising temperatures within the warhead to as high as 400 million degrees Celsius. The majority of the overall energy or yield released by a two-stage nuclear warhead is derived from the secondary (fusion) stage.

—*Abe Denmark*

See also: Fission Weapons; Fusion; Thermonuclear Bomb

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PROLIFERATION

Proliferation is the spread of knowledge or materials related to a specific type of weapon system to additional states or nonstate actors. The term has been applied primarily to the field of nuclear weapons and the spread of nuclear knowledge and capabilities. "Nuclear nonproliferation" is the prevention or deterrence of the acquisition or increase in materials, technology, or expertise utilized for the production of nuclear weapons and their delivery systems by states or subnational organizations that did not previously possess them (*see* Nonproliferation).

History and Background

The need to prevent the spread of materials, technology, or expertise related to the production of nuclear weapons was evident from the first days of the nuclear era. What gave impetus to nonproliferation efforts was the emergence of the first five declared nuclear weapons states—the United States, the Soviet Union, the United Kingdom, France, and China—and the fear that many more states would develop nuclear weapons. In addition to the declared states, there are four "de facto" nuclear states: India, Pakistan, Israel, and North Korea. Both India and Pakistan tested nuclear devices in May 1998; Israel and North Korea are widely assumed to have nuclear weapons (*see* Nuclear Weapons States).

Although the desire to acquire nuclear weapons was prevalent in the early 1960s, the introduction of full-scale commercial nuclear power as an energy source was just as promising. Developing as well as developed countries were eager to benefit from this new energy source. Nuclear technology had application in power generation, desalination, and the production of special isotopes for science and medicine. So nuclear technology flowed out of countries such as the United States and the former Soviet Union, and foreign students and scientists flowed in, eager to master nuclear technology. Peaceful nuclear technologies and expertise, however, could also be used to produce nuclear weapons. Early attempts at safeguards could not prevent covert weapons programs or the diversion of materials or technology from declared programs. If the many peaceful uses of nuclear technology were to be developed, states needed credible assurances that nuclear programs would not be used to hide programs to develop nuclear weapons.

These assurances materialized with the development of a broad range of international nuclear nonproliferation agreements, the most significant of which is the Nuclear Nonproliferation Treaty (NPT). This agreement, opened for signature on July 1, 1968, was extended indefinitely in 1995. It currently has more than 180 member nations and commits both nuclear and non–nuclear weapons states to work to prevent the proliferation of materials, technology, and expertise used in the production of nuclear weapons. This agreement is widely considered to be the cornerstone of the nonproliferation regime. The NPT represents a bargain between the original five declared nuclear weapons states and non–nuclear weapons states. The non–nuclear weapons states agreed not to manufacture or otherwise acquire nuclear weapons or other nuclear explosives and to accept international safeguards on their peaceful nuclear activities to confirm that commitment. In return, the nuclear weapons states agreed to negotiate in good faith toward ending the nuclear arms race and pursuing eventual elimination of their nuclear arsenals, not to assist non–nuclear weapons states to acquire nuclear weapons, and to make available the peaceful benefits of nuclear energy. In 1995, the Review and Extension Conference of the NPT emphasized the need for excess fissile materials to be permanently removed from the stockpiles available for weapons, concluding that these materials "should, as soon as practicable, be placed under Agency safeguards" (*see* Nuclear Nonproliferation Treaty).

Many states have entered into additional binding nonproliferation commitments. Several nuclear weapons free zones have been created, and even more restrictive nuclear agreements have been negotiated in some regions. On the Korean peninsula, for example, the Republic of Korea (South Korea) and the Democratic People's Republic of Korea (North Korea) agreed not to have facilities for either plutonium reprocessing or uranium enrichment. North Korea has chosen to abandon the nonproliferation regime by withdrawing unilaterally from both the NPT and the ban on developing weapons-grade fissile material (*see* North Korean Nuclear Weapons Program; Nuclear Weapons Free Zones).

International Compliance

The NPT and many of these other nonproliferation commitments are verified by International Atomic Energy Agency (IAEA) safeguards. IAEA safeguards are designed to detect the diversion of significant quantities of nuclear materials to construct nuclear weapons, to provide assurance that such diversions have not occurred, and to verify that states are complying with their nonproliferation obligations. The effectiveness and credibility of IAEA safeguards are fundamental to the international nonproliferation regime. Traditionally, at the instruction of the member states, the IAEA focused primarily on inspecting declared nuclear material at declared sites. In recent years, however, and particularly after the revelation of Iraq's secret nuclear weapons program, new attention has been focused on measures to detect undeclared activities at secret locations sponsored by rogue states or terrorist organizations. Under the NPT, non–nuclear weapons states are obligated to accept IAEA "full-scope" safeguards on all their civilian nuclear activities. Since the IAEA does not monitor nuclear weapons or military materials, the nuclear weapons states do not have similar obligations. The declared nuclear weapons states, however, have entered into "voluntary offer" agreements with the IAEA, under which they make certain facilities on their territory eligible for IAEA safeguards. These voluntary agreements help build confidence in the commitment of the nuclear weapons states to support international safeguards, reduce the extent of discrimination between nuclear and non–nuclear weapons states, and give the IAEA experience in safeguarding complex nuclear facilities (*see* International Atomic Energy Agency).

Supplementing these international commitments and verification regimes is a system of internationally coordinated export controls of materials and technologies that could contribute to nuclear weapons programs. The Nuclear Suppliers Group (NSG), for example, represents the major nations that provide nuclear-related products and services to other countries and meets to coordinate agreed-upon export control policies. Like IAEA safeguards, the international export control system has been significantly strengthened in recent years, particularly after revelations of Iraq's covert effort to circumvent export controls and purchase the essential technologies for a nuclear weapons program. The NSG also works to prevent nuclear materials from falling into the hands of terrorist organizations. The NSG has now agreed not to undertake major new nuclear exports to countries other than the declared nuclear weapons states that do not accept full-scope IAEA safeguards and to control the export of dual-use items. A variety of nuclear supply agreements also forms part of the international nonproliferation structure: The United States, for example, has reached bilateral nuclear cooperation agreements with the European Union, Japan, and other countries that include a range of important nonproliferation commitments, as required under the Atomic Energy Act and the Nuclear Nonproliferation Act of 1978 (*see* Nuclear Suppliers Group).

Security for nuclear materials and other measures to prevent nuclear theft and smuggling also are key international efforts to prevent the spread of nuclear weapons. States handling nuclear materials bear the primary responsibility for ensuring their security. Given the dire threat posed by the possibility of terrorists or rogue states gaining access to plutonium or highly enriched uranium (HEU), the international community has a legitimate interest in ensuring the adequacy of states' protection of these materials. The international Convention on the Physical Protection of Nuclear Materials, which entered into force on February 8, 1997, specifies physical protection measures that should be applied, particularly in international shipments of nuclear materials. The NSG guidelines also specify measures to be taken by states receiving materials from NSG member states. In addition, the International Atomic Energy Agency has issued nonbinding recommendations on security measures to be taken to safeguard nuclear materials. All of these guidelines, however, are expressed in broad and general terms to allow for substantial differences in approach to achieve these common objectives. Some states, for example, rely primarily on armed guards to ensure security at nuclear facilities, while other states have no armed guards at all, even at facilities with substantial quantities of plutonium and HEU, and instead rely on high technology to alert authorities of potential instances of foul play. The economic, political, and social transformations recently experienced by states that were once part of the Soviet Union have significantly weakened security at many nuclear facilities, creating new nuclear proliferation concerns that represent part of the rationale for carrying out disposition of excess fissile materials.

Many factors influence national decisions to acquire or not acquire a nuclear arsenal. Preventing nuclear proliferation in the long run will require strenuous efforts to address both the "supply side" and the "demand side" of a nuclear weapons program. Thus, for example, efforts to resolve conflicts in the Middle East, South Asia, and elsewhere represent key parts of the global nonproliferation effort to combat the "demand side" of weapon acquisition. In many cases, nontechnical considerations, rather than technical ones, may dominate not only whether a country decides to pursue nuclear weapons but also its ability to acquire a nuclear arsenal. These factors, which are country dependent, include the ability of a government to organize, manage, and carry through complex, long-term projects involving a large scientific and technological infrastructure, and to keep state secrets. A country's foreign trade contacts, its supply of hard currency, and its political will to become a "member" of the nuclear club also shape the nature of its nuclear weapons program.

Technical Challenges to Proliferation

To acquire nuclear weapons, a state must overcome a number of technical hurdles. It must obtain enough fissile material to form a supercritical mass (thus permitting an explosive chain reaction) (*see* Criticality and Critical Mass). It must produce a weapon design that will bring that mass together in the time allotted, before the heat from early fissions blows the material apart. It also must design a weapon small and light enough to be carried by available delivery vehicles. These hurdles represent threshold requirements for use of a weapon. Unless each one is adequately met, the proliferator ends up not with a less powerful weapon, but with a device that cannot produce any significant nuclear yield or that cannot be delivered to its intended target. Limited access to the principal weapon-usable materials has been for many years the primary technical barrier against the spread of nuclear weapons capabilities to additional nations and to subnational groups. The technologies for producing separated plutonium and HEU are demanding and costly. The plutonium and HEU that have been produced by weapons states generally have been well guarded or have resided in forms awkward to steal and difficult to use in weapons (for example, plutonium contained in spent nuclear reactor fuel that is not separated from accompanying uranium and fission products). In contrast, the basic knowledge and expertise needed to make at least crude nuclear weapons is available to virtually any country or subnational group or terrorist organization. Therefore, the ability to buy fissile materials on a nuclear black market could circumvent this important roadblock to the proliferation of nuclear weapons (*see* Highly Enriched Uranium; Plutonium; Uranium).

There are few radioactive isotopes capable of sustaining an explosive chain reaction: two isotopes of uranium (U-233 and U-235) and several isotopes of plutonium (especially Pu-239, Pu-240, Pu-241, and Pu-242) (*see* Isotopes).

Uranium 235 is the only potential nuclear explosive isotope that occurs naturally in significant quantities. It constitutes 0.7 percent of natural uranium, so its nuclear explosive properties emerge only if the proportion of U-235 atoms in the uranium is much higher than in the natural element. Nuclear explosives can in principle be made with material containing somewhat less than 20 percent U-235, but the amount of material required at that level of enrichment is very large. In international practice, all uranium with a U-235 concentration of 20 percent or more is referred to as highly enriched uranium (HEU). For fission explosives, nuclear weapon designers prefer a U-235 fraction of more than 90 percent, and HEU in this concentration range is called "weapons-grade." Increasing the U-235 concentration above its level in natural uranium—uranium enrichment—is a technologically demanding and costly enterprise. Enrichment techniques include gaseous diffusion, gas centrifuge, aerodynamic methods (Becker nozzle), chemical exchange (Chemex process), electromagnetic isotope separation, laser excitation, and plasma centrifuge (*see* Enrichment).

Plutonium is nonexistent in nature but can be produced by bombarding U-238 with neutrons in a nuclear reactor or an accelerator. (U-238 is the most abundant uranium isotope, constituting 99.3 percent of natural uranium.) Reactors have proven to be more practical than accelerators for producing plutonium in large quantities. To use the plutonium produced in a nuclear reactor in a nuclear weapon, it first must be chemically separated from the other fission products produced with it and from the residual U-238. This separation process, called "reprocessing," also is a technically demanding and costly operation. Because of the intense gamma radioactivity of fission products and the health risks posed by the alpha activity of plutonium if it is inhaled or otherwise taken into the body, reprocessing also requires stringent measures to mitigate its health and safety hazards. Although virtually all combinations of plutonium isotopes can be used to manufacture nuclear explosives, nuclear weapons designers prefer to work with plutonium containing more than 90 percent Pu-239 (weapons-grade plutonium). This high Pu-239 concentration is commonly achieved by removing the plutonium from the reactor before the higher isotopes, which result from successive neutron absorptions, have a chance to build up. The longer refueling intervals typical of civilian nuclear electricity generation result in plutonium that contains only 60–70 percent Pu-239 (reactor-grade plutonium).

Reactor-grade plutonium can nonetheless be used to produce nuclear weapons. Three characteristics of reactor-grade plutonium, however, pose difficulties for weapons design and manufacture: Its high neutron background increases the likelihood of "pre-initiation" of the nuclear chain reaction just before the weapon reaches the optimum configuration for maximum yield; its tendency to generate heat while in storage may affect the stability and performance of the weapon's components; and its high radioactivity creates great danger for those fabricating and handling weapons produced from reactor-grade plutonium. The more sophisticated the weapon design, the more likely these difficulties can be overcome. Unsophisticated designers could make crude but highly destructive nuclear bombs from reactor-grade plutonium, using technology no more sophisticated than that required for making similar bombs from weapons-grade plutonium, and sophisticated designers could use reactor-grade plutonium to make very effective nuclear bombs quite suitable for the arsenals of major nation-states.

A state or subnational group using designs and technologies no more sophisticated than those used in first-generation nuclear weapons could build a nuclear device from reactor-grade plutonium that would have a reliable explosive yield of between 1 and 20 kilotons. At the other end of the spectrum, advanced nuclear weapons states such as the United States and Russia, using modern designs, could produce weapons from reactor-grade plutonium having reliable explosive yields, weight, and other characteristics generally comparable to those of weapons made from weapons-grade plutonium.

The quantities of weapons-usable material needed to make a nuclear weapon are not large. Although the amounts used in specific nuclear weapon designs are classified, numbers in the range of 4 to 6 kilograms of plutonium metal are widely cited in the unclassified literature as typical (and the figure would not be very different if reactor-grade rather than weapons-grade plutonium were used). A comparison of critical masses suggests that obtaining a comparable explosive yield from weapons-grade HEU would require a mass of uranium metal approximately three times greater. The required amounts of material can be easily carried by one person and easily concealed. These materials themselves are not radioactive enough to deter theft and handling. Because of the very long half-lives of Pu-239 (24,000 years) and U-235 (700 million years), the radiological dose rates from these materials are orders of magnitude lower than those that arise, for example, from spent fuel when it is unloaded from a nuclear reactor, which contains intensely radioactive fission products such as cesium 137 and strontium 90.

Weapons Designs

With access to sufficient quantities of fissile materials, most nations and even some subnational groups would be capable of producing a nuclear weapon. Nuclear weapons are generally gun-type and implosion-type designs. Both types use fissile material, and several designs make use of the fusion of lighter elements to improve weapon efficiency and "boost" the energy release. Similar components are present in each design: chemical explosives to assemble the fissile material into a supercritical mass that will sustain an explosive chain reaction; nonfissile materials to reflect neutrons and tamp the explosion; electronics to trigger the explosion; a neutron generator to start the nuclear detonation at the appropriate time; and associated command, control, and, if needed, guidance systems (*see* Gun-Type Devices; Implosion Devices).

The gun-type design is the simplest nuclear weapon. Gun-type designs use U-235 or U-233 as the fissile material. The fissile material is kept in the form of two subcritical hemispheres that when brought together form a supercritical mass. Tampers, made of a heavy material placed around the fissile material in both hemispheres, contain the fissile material for the amount of time needed to produce the desired yield. The tampers also act as a neutron reflector. The nuclear explosion is initiated by detonating a high-explosive propellant behind one of the hemispheres, which accelerates rapidly down the barrel toward the other. At the instant the two hemispheres meet, a burst of neutrons is injected to initiate the chain reaction. The primary advantage of gun-type design is simplicity. It is as close to a foolproof design as technology allows. The drawback to the gun-type design is that low compression requires large amounts of fissionable material and leads to low efficiency. Only about 3 percent of the material is fissioned by a gun-type design, and only U-235 and U-233 can be used owing to the slow insertion speed of the device. The weight and length of the gun barrel makes the weapon heavy and long.

The implosion-type design makes use of the fact that increasing the density of the fissile material decreases the critical mass required for a supercritical state. This is the principle employed in most modern nuclear weapons designs. The fissile material is in the form of a small subcritical sphere surrounded by a tamper. Outside this is a high explosive, which is detonated simultaneously at a number of points on the exterior to produce a symmetrical, inward-traveling shock wave. This "implosion" compresses the fissile material two to three times its normal density. At the moment of maximum compression, a burst of neutrons is injected to initiate the chain reaction. The implosion-type design creates a high insertion speed that allows materials with high spontaneous fission rates (such as plutonium) to be used. Implosion devices are lightweight and efficient weapons that use relatively small amounts of material. Advanced implosion-type designs are complex and require extensive research and testing and high-precision machining and electronics. Imprecise timing and lack of a simultaneous detonation will cause the weapon to malfunction.

Today, proliferation of all weapons of mass destruction is a pressing global security issue. As dual-use technologies spread across the globe, policymakers are becoming increasingly concerned that existing arms control and nonproliferation regimes are failing to stop the spread of chemical, biological, nuclear, and radiological weapons and that it may be only a matter of time before these weapons are either stolen or manufactured by terrorists. Today, the greatest impediment to the proliferation of nuclear weapons into the hands of state and nonstate actors is the international regime to safeguard fissile materials.

—D. Shannon Sentell, Jr.

See also: Proliferation Security Initiative

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PROLIFERATION SECURITY INITIATIVE

The Proliferation Security Initiative (PSI) is a cooperative effort initiated by the United States in 2003 to interdict shipments of weapons of mass destruction, their delivery systems, and related materials to and from states and nonstate actors of proliferation concern. In May 2003, the United States began working with ten like-minded countries (Australia, France, Germany, Italy, Japan, the Netherlands, Poland, Portugal, Spain, and the United Kingdom) to develop PSI. On September 4, 2003, PSI participants committed to a Statement of Interdiction Principles, vowing to take measures to interdict proliferation-related shipments; to streamline related information sharing; to enforce and strengthen relevant national and international law; and to take other specified steps to facilitate interdiction of proliferation-related cargoes. Canada, Norway, and Singapore have subsequently begun participating in PSI plenary meetings, and more than sixty states have endorsed the initiative's objectives. As President George W. Bush said in his May 2003 speech in Poland, "We will extend participation in PSI as broadly as possible to keep the world's most destructive weapons away from our shores and out of the hands of our common enemies."

In the PSI's first year, participants took several steps to improve their operational capacity to interdict shipments of concern. They conducted nine training exercises to practice interdicting proliferation-related shipments and held regular meetings, including five operational experts meetings. The United States is pursuing PSI boarding agreements with key flag states to facilitate interdictions of proliferation-related shipments on those states' vessels; the first such agreement was signed with Liberia on February 11, 2004. In October 2004, Japan hosted the first PSI exercise in Asia.

Although PSI participants at the June 2003 meeting in Brisbane, Australia, identified North Korea and Iran as states of particular concern, PSI is a global initiative and is aimed against proliferation-related shipments to and from all states and nonstate actors of proliferation concern. For example, in October 2003 German and Italian authorities, acting on information from U.S. and UK intelligence, stopped a shipment of advanced centrifuge parts bound for Libya.

—Michael Lipson

See also: Nonproliferation; Proliferation

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PUGWASH CONFERENCES

Since 1957, the Pugwash Conferences on Science and World Affairs have brought together influential scientists, scholars, and public figures interested in reducing the danger of nuclear war and seeking cooperative solutions to world problems. After the events at Hiroshima and Nagasaki, Japan, in August 1945 and the subsequent expansion of nuclear forces by both the United States and the Soviet Union, many scientists began to discuss the moral implications of their work. The true driving force behind Pugwash, though, was philosopher Bertrand Russell. He obtained the support of key figures, such as Albert Einstein, and in 1955 they issued the Russell-Einstein Manifesto describing the potential horrors of a nuclear war and calling for a conference featuring top scientists from around the world to discuss ways to reduce the risk of nuclear war. The idea caught the attention of industrialist and philanthropist Cyrus Eaton, who offered to finance the conference and host it at his summer home in Pugwash, Nova Scotia. The 1957 conference was considered a huge success, so the meetings became regular events. Its founders argued that Pugwash could apply the scientific method of analyzing a problem to contentious scientific and political issues.

The first Pugwash Conference brought together twenty-two participants from ten countries, including the United States, England, the Soviet Union, and China. The hope was that the participants could bring ideas back to their own governments. Also, by building personal contacts, the scientists could increase confidence in their opponents' rationality, a concept central to deterrence. Physicist Joseph Rotblat, who had worked on the Manhattan Project, led the conference and became the leader of the group for the next forty years. Despite their diverse backgrounds, the participants agreed on certain technical issues and, even more important, on the idea that scientists had social responsibilities and should be part of future policy debates.

The original Russell-Einstein Manifesto and the first meeting generated significant press attention, and Pugwash quickly became well known in policymaking circles as well as among the general public. The group did its best to remain politically independent, and meeting participants always came as individuals, not representatives of their countries. The group also chose not to have a constitution or formal structure so that participants of different perspectives would remain equals. Some observers, however, portrayed the group as too soft, or even sympathetic to communism, because its calls for preventing war and pursuing disarmament overlapped somewhat with Soviet propaganda. Others noted the heavy percentage of the group who served as U.S. or British advisers and questioned whether it was a tool of those governments.

Over the years, Pugwash has chosen to remain a small group with attendance by invitation only rather than opening its meetings to the public. Although most participants are physical scientists, the number of social scientists has increased over time. By 2002, there had been more than 275 Pugwash conferences or workshops with over 3,500 participants. Most of the group's early conferences were focused on nuclear policy and the Cold War. Now, its scope has expanded to include proliferation, chemical and biological weapons, land mines, regional disputes, and ethical problems tied to other scientific advances. The group has tried to encourage more women and more young scientists to become members, but there is some question whether Pugwash will survive after its leading figures retire or die.

Supporters credit the group with serving as an important link between East and West during the Cold War, with helping shape policy debates globally, and with encouraging arms control ideas. Pugwash has received numerous awards, including the 1995 Nobel Peace Prize.

—John W. Dietrich

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Q

QUADRENNIAL DEFENSE REVIEW

The first Quadrennial Defense Review (QDR) of 1997 was the fourth comprehensive review of the U.S. military since the end of the Cold War. It built upon the experience of the 1991 Base Force Review, the 1993 Bottom-Up Review, and the 1995 Commission on Roles and Missions of the Armed Forces. It was mandated by the 1997 Military Force Structure Review Act and was designed by the U.S. Department of Defense to be a comprehensive examination of America's emerging defense needs between 1997 and 2015.

The QDR covers issues of potential threat, strategy, force structure, readiness levels, deployment patterns, infrastructure, and modernization. The review has served as a model for nations' efforts to realign their military force structures. The United Kingdom, for example, conducted a 1998 Strategic Defence Review.

The QDR is designed to be a collaborative effort between the U.S. secretary of defense and the Joint Chiefs of Staff and may be modified to reflect the changing world situation. The 1997 QDR followed the Bosnian War, and the 2001 QDR was finalized in the immediate aftermath of the terrorist attacks of September 11, 2001. The next one is scheduled for 2005.

—Andrew M. Dorman

See also: Bottom-Up Review; Joint Chiefs of Staff; Nuclear Posture Review; United States Nuclear Forces and Doctrine

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R

RADIATION

Ionizing radiation is one of the three principal effects produced by a nuclear explosion, along with blast and thermal radiation. It is composed of alpha particles, beta particles, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this context, does not include nonionizing radiation.

Technical Details

All material is composed of atoms. Atoms, in turn, are composed of a nucleus, which contains minute particles called protons and neutrons, and an outer shell made up of particles called electrons. The nucleus carries a positive electrical charge, and the electrons carry a negative charge. As electrons are bound to the nucleus of the atom, so are the particles within the nucleus. These forces work toward a strongly stable balance. The process by which the nuclei of atoms work toward becoming stable is to get rid of excess energy. Unstable nuclei may emit a quantity of energy, or they may emit a particle. This emitted atomic energy or particle is called "radiation." A nuclear explosion produces ionizing radiation. The process by which atoms gain or lose electrons is called "ionization." In ionizing radiation, the energy from the radiation is sufficient to remove electrons from atoms, leaving two positively charged particles (ions) behind. Some forms of radiation, such as visible light, microwaves, or radio waves, do not have sufficient energy to remove electrons from atoms. They are called "nonionizing radiation."

A nuclear explosion creates four kinds of radiation—alpha, beta, gamma, and neutron. Only three of these are significant to this discussion: alpha, beta, and gamma.

Alpha radiation has low penetrating power and a short range (a few centimeters in air). Because of this short range, the danger to the external surface of the human body is negligible. The most energetic alpha particle will generally fail to penetrate the dead layers of cells covering the body and can be easily stopped by a sheet of paper. Alpha particles are hazardous if allowed to enter the body through a break in the skin, ingestion, or the respiratory tract, however. Once inside the body, the alpha particles, with their high ionizing ability, will expend their energy into a single group of cells. This causes a very high degree of localized tissue damage. Alpha emitters present an internal hazard twenty times as great as beta or gamma emitters.

Even though airborne beta particles can travel significant distances, solid materials will stop them. Beta emitters present two potential external radiation hazards: the beta particles themselves and the X-rays they can produce when they strike certain materials, such as lead. Although beta particles can travel significant distances in air, materials such as aluminum, plastic, or glass provide appropriate shielding. However, these emitters should be handled with care. Because the lens of the eye is radiosensitive, eye protection such as goggles or a protective mask is recommended.

Gamma radiation does not consist of particles, it has no electrical charge, and science has demonstrated that it has no mass. Gamma radiation is far more dangerous than alpha or beta because its rays are more penetrating and harmful. How successfully one is protected depends on the type, density, and thickness of the shielding. Simply stated, as the thickness of the shielding increases, the penetration of the gamma radiation decreases. Higher density materials such as lead, tungsten, concrete, and steel can be effective shields against gamma emissions.

Although radiation is perhaps the best-known effect of nuclear weapons, it accounts for only 15 percent of the destructive force of the explosion. This includes initial radiation (neutrons and gamma rays), which is emitted within the first minute after detonation, and residual nuclear radiation, which is emitted after the first minute.

Approximately 5 percent of the energy released in a nuclear burst is transmitted in the form of initial neutron and gamma radiation. The neutrons result almost exclusively from the energy produced by the fission and fusion reactions. The initial gamma radiation arises from these reactions as well as from the decay of short-lived fission products. The intensity of the initial nuclear radiation decreases rapidly with distance from the point of burst. The character of the radiation received at a given location also varies with distance from the explosion. Near the point of the explosion, the neutron intensity is greater than the gamma intensity, but it diminishes quickly with distance. The range for significant levels of initial radiation does not increase markedly with weapon yield. Therefore, initial radiation actually becomes less of a hazard with increasing yield, as individuals close enough to be significantly irradiated are killed by the blast and thermal effects.

Residual Radiation (Fallout)

Residual radiation from a nuclear explosion accounts for 10 percent of the energy released and primarily takes the form of fallout. Fallout is created when a nuclear weapon surface burst vaporizes large amounts of earth or water because of the heat of the fireball. This debris is drawn up into the radioactive "mushroom" cloud, especially if the explosive yield exceeds 10 kilotons. This material becomes radioactive and will eventually settle to earth as fallout. The area and intensity of the fallout is strongly influenced by local weather conditions. Much of the material is simply blown downwind, forming a plume-shaped pattern on the ground. Rainfall can also have a significant influence on the ways in which fallout is deposited, since rain will carry contaminated particles to the ground. The areas receiving such contaminated rainfall become "hot spots" with greater radiation intensity than their surroundings.

Severe local contamination can extend far beyond the limits of the blast and thermal effects, particularly in the case of high-yield surface detonations. The danger from fallout lessens with time. This lessening is called "decay." In technical terms, radioactive decay is the process by which large, unstable atoms become more stable by emitting radiation. The radiation can be in the form of a positively charged alpha particle, a negatively charged beta particle, or gamma rays.

—*Jeffrey A. Adams*

See also: Fallout; Neutrons; Nuclear Weapons Effects; Radiation Absorbed Dose (Rad); Roentgen Equivalent Man (Rem)

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RADIATION ABSORBED DOSE (RAD)

The radiation absorbed dose, or "rad," is a measurement of the energy absorbed by any material (for example, water, human tissue, or air) as it passes through a field of ionizing radiation. It is a unit of absorbed dose. "Absorbed dose" is that radiation which is actually absorbed into material (such as the human body). The term should not be confused with "exposure dose," which is radiation available to be absorbed. A rad of one type of radiation does not necessarily produce the same biological effect as a rad of another kind. The difference in biological effectiveness is given in terms of the relative biological effectiveness (RBE).

One rad is the absorption of 100 ergs of energy per gram of absorber. An erg is an extremely small amount of energy. To raise a 1-pound weight the distance of 1 foot, for example, would require about 13.6 million ergs.

Another unit of absorbed dose is the Roentgen equivalent man (rem). One rem is an absorbed dose of any ionizing radiation that will produce the same biological effect in man as the absorbed dose from exposure to 1 roentgen of X-ray or gamma radiation.

—*Jeffrey A. Adams*

See also: Radiation; Roentgen Equivalent Man (Rem)

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RADIOLOGICAL DISPERSAL DEVICE

Radiological dispersal devices (RDDs) cause contamination and health risks by dispersing radioactive substances into a populated area. The most spectacular type of RDD is the so-called dirty bomb. In a dirty bomb, radioactive material is wrapped around a conventional explosive and detonated, contaminating the surroundings. Unlike nuclear weapons, dirty bombs do not involve a nuclear chain reaction but rely on the innate radioactivity of the materials released.

Radioactive substances are widely available in society because of their use in industry, medicine, and research. Substantial contamination would require highly radioactive materials that are difficult to procure and to handle. The amount of radioactive material used, dispersal effectiveness, exposure time, and exposure patterns would all influence the risk of acute death from a dirty bomb, but generally the risk of lethal exposure from an RDD is low. The danger to health and life is thus primarily due to long-term effects (for example, increased cancer risks). The use of RDDs could create a strong psychological impact and widespread panic.

Terrorists could spread radioactive substances simply by pouring out or dispersing the material in high-traffic areas. Decontamination could be very difficult, time consuming, and expensive. Food and drinking water also could be contaminated, again with huge societal and economic losses. More sophisticated perpetrators could use spreading devices to contaminate the air with radioactive dust.

A team from the Seattle Fire Department participated in this May 2003 simulation of a "dirty bomb" incident. (Reuters/Corbis)

In 1995, Chechnyan rebels threatened to blow up several assembled dirty bombs in Moscow, but the threats were never carried out. Although government officials across the globe are concerned that terrorists will employ a dirty bomb against a civilian target, their worst fears have not become a reality.

—Morten Bremer Maerli

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THE RAND CORPORATION

The RAND Corporation was the first and most influential of the "think tanks" that arose in the years following World War II to explore the impact of the advent of nuclear weapons on the character and conduct of war.

In 1946, the Air Materiel Command signed a $10 million, three-year contract with Douglas Aircraft Corporation to found Project RAND (its name based on the initials for "research and development"). In 1948, the group split from Douglas and became the independent RAND Corporation.

The RAND Corporation pioneered the development of nuclear strategy in the years following World War II. It was home to some of the most influential U.S. nuclear strategists, including Bernard Brodie, Thomas Schelling, and Albert Wohlstetter. Working in an environment that was largely devoid of bureaucratic constraints, RAND researchers developed many of the concepts that became fundamental to nuclear strategy and deterrence theory, such as first- and second-strike forces, escalation, and stability. A number of RAND alumni, including James Schlesinger and Andrew W. Marshall, later held influential positions within the U.S. Defense Department.

RAND also conducted a number of important studies of military technology. RAND analysts were among the first to argue, in December 1950, that an intercontinental ballistic missile was feasible and to explore the possibility of using an artificial satellite to conduct reconnaissance.

—Tom Mahnken

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RAPACKI PLAN

The Rapacki Plan of the early 1950s was the first nuclear weapons free zone (NWFZ) formally proposed in an international forum. Put before the twelfth session of the United Nations General Assembly by Polish foreign minister Adam Rapacki, the plan proposed banning the manufacture and deployment of nuclear weapons in Central Europe, including Poland, Czechoslovakia, the German Democratic Republic (GDR), and the Federal Republic of Germany. Nuclear-armed states would be expected to respect the nonnuclear status of the region and not use or deploy nuclear weapons anywhere in the NWFZ. The plan was to be ratified by all signatories, and verification and compliance with its provisions would be monitored by a commission made up of neutral states as well as members of the Warsaw Pact and the North Atlantic Treaty Organization (NATO).

NATO rejected the proposal on the grounds that it failed to limit conventional forces in the region and to address the issue of German reunification. Rapacki responded in 1958 with a new proposal for phased nuclear reductions in the region. Under the new plan, a nuclear freeze would be followed by negotiated reductions in existing stockpiles maintained in the proposed NWFZ.

Soviet and Polish officials advanced the Rapacki Plan as a way to prevent West Germany from obtaining access to NATO nuclear weapons and as a vehicle to gain Western recognition of the GDR. Polish officials also viewed it as a way for smaller members of the Warsaw Pact to open trade and cultural relations with NATO. The failure of Rapacki's initiative heralded the onset of Soviet-U.S. acrimony over a divided Germany that culminated in the second Berlin Crisis that began to heat up in 1958 and culminated in 1961.

—*James J. Wirtz*

See also: Cold War; Nuclear Weapons Free Zones

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RAROTONGA, TREATY OF

See Nuclear Weapons Free Zones (NWFZs)

RATIFICATION

Ratification is a process whereby a treaty is formally approved by a sovereign governing entity (usually a state or group of states). Ratification follows treaty negotiation and is normally a prelude to implementation. Often, treaties negotiated by the executive branch of a government are ratified by the legislative branch; in the United States, for example, the Constitution (Article II, Section 2) explicitly states that the president "shall have the Power, by and with the Advice and Consent of the Senate, to make treaties, provided two thirds of the Senators present concur" (although the president can also make "congressional-executive agreements" that are "ratified" with only a majority from both the Senate and the House).

The Vienna Convention on the Law of Treaties, drafted in 1969, and which entered into force in 1980, codified international customary treaty law. Although the United States is not a party to the Vienna Convention, it nonetheless recognizes the convention's binding nature because it restates already accepted international laws. The Vienna Convention defines ratification as "the international act so named whereby a State establishes on the international plane its consent to be bound by a treaty."

Generally, individual treaties contain provisions specifying how many nations must actually ratify the treaty for it to enter into force. In terms of the Comprehensive Test Ban Treaty (CTBT), for example, forty-four states—those possessing nuclear power or research reactors at the time of the 1996 United Nations Conference on Disarmament, where the CTBT was negotiated—must sign and ratify the CTBT for it to enter into force. Only thirty-two of those states had done so as of mid-2004. (The United States is among those which have not ratified the treaty.) The ratification process highlights the potential for domestic political concerns to influence international attempts to regulate weapons of mass destruction.

—*William D. Casebeer*

See also: Arms Control; Comprehensive Test Ban Treaty; Entry into Force; Implementation; Underground Testing; Verification

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REACTOR OPERATIONS

"Reactor operations" is a broad term that can be interpreted to mean a number of different operations associated with nuclear power plants. A nuclear reactor is a device that controls and sustains the nuclear fission process for extended periods of time to harness the associated energy or to conduct research. "Reactor operations" refers to the nonnuclear and nuclear components of a nuclear power plant that are necessary to harness fission energy in the form of heat and convert that energy to electricity. The term may also refer to reactor core operations, the day-to-day operations of a nuclear power plant, or other procedures associated with nuclear power plants.

Background

The first reactor was designed and built by Enrico Fermi at Stagg Field Stadium, University of Chicago, on December 2, 1942. Fermi achieved this first self-sustaining nuclear chain reaction for research purposes. The first reactor that supplied power, designed, built, and operated in December 1951 by Argonne National Laboratory, was the Experimental Breeder Reactor (EBR-1) at the Nuclear Reactor Testing Station in Arco, Idaho. Argonne National Lab also built a prototype pressurized water reactor submarine in 1953 that produced electrical power and was an important predecessor to the first commercial power reactor built by the United States.

The first nuclear power plant built and operated in the Soviet Union was a 5-megawatt reactor that

Inside a functioning graphite reactor at Chernobyl, Ukraine, 1996. (Kleschuk Anatoly/Corbis Sygma)

began operation in 1954. England built a nuclear power plant for commercial purposes in 1956, a 50-megawatt gas-graphite reactor at Calder Hall in Cumbria, England. The first central-station nuclear power plant in service in the United States was the 60-megawatt Shippingport pressurized-water reactor (PWR), which went into operation on December 2, 1957, in Shippingport, Pennsylvania.

Technical Details

Nuclear power plants are much like any other power plant (for example, fossil fuel–burning power plants) because the objective is to burn fuel that will generate heat, which is used to produce steam. Steam is then used to turn turbines, which generate electrical power. The difference between nuclear and conventionally fired reactors is that nuclear power plants burn nuclear fuel in the fission process in the form of fissile material as opposed to burning coal or another fossil fuel.

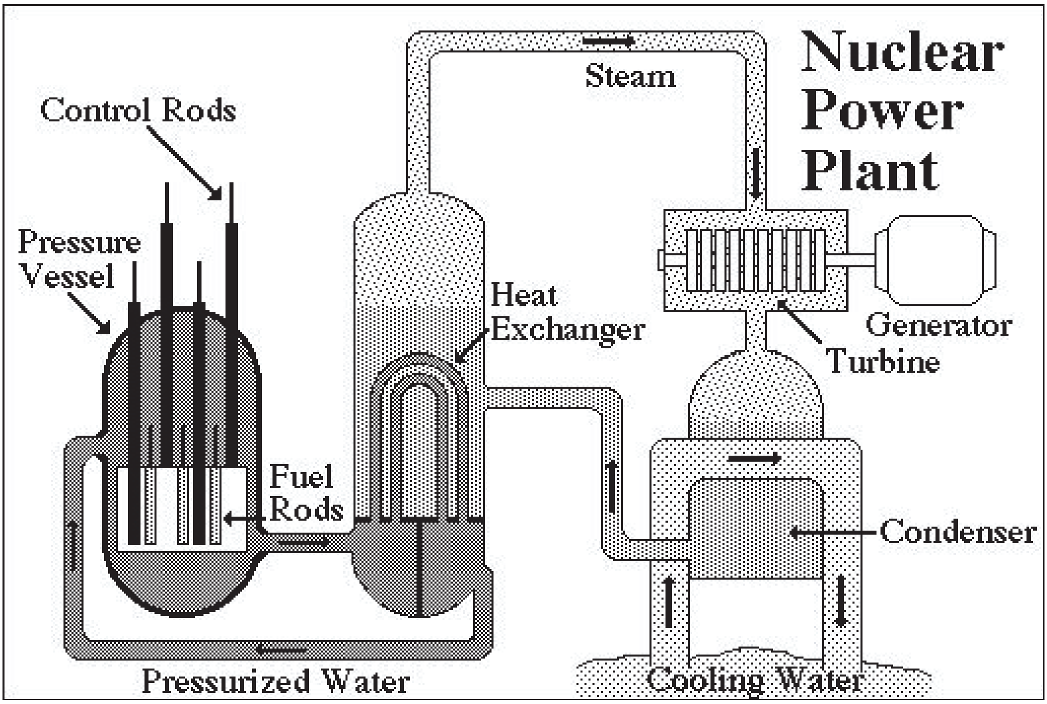
Even though there are many different reactor designs, nuclear power plants have common components. All nuclear power plants have a reactor core with associated fuel, moderator, coolant, and shielding materials; a boiler, condenser, and turbines used to generate electrical power; and control and safety features. Figure R-1 is a diagram of a pressurized-water reactor and illustrates the basic components of a nuclear power plant.

The core of a nuclear reactor is where the sustained nuclear chain reaction is accomplished and the energy from fission released. The heat generated by the reactor core is used to boil water, which turns turbines to generate electrical power. The reactor core is generally composed of the nuclear fuel or fissile material, coolant, reflector material, moderator (if the reactor uses thermal neutrons to sustain the chain reaction), and reactor control material.

The control of neutrons in the reactor core is essential to reactor operations. In order for a reactor to sustain a nuclear chain reaction, each generation of fissions must generate enough neutrons to cause another generation of fissions to occur. As neutrons escape from nuclei during the fission process, they may be absorbed or captured by the nuclei of materials in the reactor, they may escape or leak out of the reactor core entirely, or they may cause other nuclei to fission.

Fortunately, the most common fissile fuel used in nuclear reactors in the United States, uranium 235, releases an average of 2.4 neutrons for every fission event. Reflector material is used to scatter neu-

Figure R-1: Pressured Water Reactor



Source: http://www.hibbing.tec.mn.us/programs/dept/chem/V.11/page_id_70977.html.

trons back toward the fissile material, thereby precluding their escape from the reactor core. Moderator material is used to slow neutrons down to energy levels that are conducive to causing fission. Coolant in the core is used to ensure that the core materials do not "melt down" due to excessive heat caused by the fission process. Control rods also may be added to the core to control how many neutrons are present. Control rods generally absorb neutrons, which means that there would be fewer neutrons to cause fission events when they are inserted. The reactor core vessel is designed with the shielding materials necessary to shield workers and the environment from the harmful effects of the radiation associated with the fission process.

The boiler and condenser are two basic components of a nuclear power plant. The boiler is the device in which water is allowed to boil to generate steam. The steam is then used to turn turbines. These turbines generate electricity. After the steam is used to turn the turbines, it is diverted to a condenser, where the steam is cooled to become water.

Control and safety features for nuclear power plants became the focus of intense scrutiny by the nuclear regulatory commission and other governing bodies after the Three Mile Island accident in March 1979 near Harrisburg, Pennsylvania. The main purpose of these control and safety features is to control the environment within the reactor core. Control rods play an important role in controlling the number of neutrons, and thereby the number of fissions, that occur in the core.

Other than the number of fissions occurring in the core, another major concern is the temperature of the reactor core. Coolant is critical to maintaining the temperature of the core. Without coolant present, the fission process would generate enough heat to melt the material of the reactor core. Emergency safety features have been implemented to prevent a loss of coolant accident (LOCA). One of these safety features is the emergency core cooling system (ECCS), which is capable of introducing more coolant into the core using both passive and active systems. The passive system is essentially large accumulator tanks that hold water to be introduced to the core in the event of a large break in the coolant system. The active system includes a series of high- and low-pressure coolant injection systems, which are used to maintain the proper level of coolant.

Nuclear Power Today

Nuclear reactors are operating in countries throughout the world. Thirty-one countries use approximately 440 reactors to supply commercial power, and 56 countries operate more than 280 reactors for research purposes. Nuclear reactors supply approximately 17 percent of the world's electricity needs.

There are currently 104 commercial nuclear reactors operating in the United States that supply approximately 20 percent of the nation's power. Additionally, there are approximately 36 research reactors operating in 23 states in the United States.

With increasing concerns about the environment and emissions of pollutants from fossil fuel–burning power plants, reactor operations offer an alternative energy source. Operating a nuclear power plant is generally better for the environment than fossil fuel–burning plants in terms of the production of greenhouse gases. Nuclear power plants produce no nitrous oxides, sulfur dioxides, or carbon dioxides and emit only very small amounts of radioactive gases.

Reactor operating costs for a nuclear power plant also offer advantages to nuclear power. Even though there is a considerable front-loaded capital cost to build and license a nuclear reactor, the fuel and operating costs are relatively inexpensive compared to some types of electric plants that rely on fossil fuel.

—Don Gillich

See also: Canada Deuterium Uranium Reactor; Fast Breeder Reactors; Gas-Graphite Reactors; Light-Water Reactors; Mixed Oxide Fuel; Neutrons; Nuclear Fuel Cycle; Pressurized-Water Reactors; Research Reactors; Three Mile Island; Uranium

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REASONABLE SUFFICIENCY

In 1985, Soviet President Mikhail Gorbachev launched the policies of glasnost (openness) and perestroika (restructuring), embarking on a path that culminated in the end of the Warsaw Pact, the Soviet Union, and the Cold War. Gorbachev hoped to revitalize Soviet communism to make it increasingly competitive with the capitalist West. As part of this program, he sought to reduce international tension and Soviet defense spending so that Russia's natural resources and Western aid and trade might be used to revitalize the Soviet economy. To accomplish this goal, Gorbachev began to describe Soviet nuclear doctrine as being based on "reasonable sufficiency." At a meeting in Berlin in May 1987, reasonable sufficiency was adopted as policy by the Warsaw Pact.

Reasonable sufficiency rejected traditional Soviet military doctrine, which had been based on the notion that offense was the best type of defense. Under that doctrine, if the threat of war loomed with the United States or the North Atlantic Treaty Organization (NATO), Warsaw Pact forces would launch an offensive thrust using both nuclear and conventional weapons to destroy NATO forces and occupy all of Europe to the Atlantic coast. Reasonable sufficiency abandoned the idea of preventive war or preemptive attack, reduced the capability of Soviet mechanized forces to attack Western Europe, eliminated theater nuclear forces, and cut conventional capabilities to a level equal to NATO forces. Warsaw Pact units would retain some offensive capability to counter a NATO attack or to intervene if revolution threatened Communist regimes that controlled Eastern Europe. Reasonable sufficiency slowly emerged as a truly "defensive" form of defense.

Reasonable sufficiency elicited much NATO interest in reciprocal force reductions, confidence-building measures, and other diplomatic initiatives that demonstrated to all concerned that it was possible to break the cycle of armament and mistrust that animated the Cold War in Europe.

—James J. Wirtz

See also: Cold War

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RECIPROCAL FEAR OF SURPRISE ATTACK

The concept of a reciprocal fear of surprise attack focuses on the circumstances that may allow for the possibility of an accidental war breaking out during a peaceful but tense situation. The theory rests on the fact that it is theoretically possible to seize a tremendous advantage by striking first in a nuclear conflict. A preemptive nuclear strike against an opponent's command structure, communications network, and nuclear capabilities may cripple or completely eradicate the opponent's ability to retaliate. Since both sides of a conflict are aware of this advantage, there is a necessary premium on mobilizing a swift and decisive assault. Because of the reciprocal fear of surprise attack, both sides would be tremendously sensitive to the actions of the other side, increasing their readiness to unleash a devastating preemptive strike before the other side was capable of doing the same.

The reciprocal fear of surprise attack is the primary motivating factor that some believe can accidentally lead to a large-scale nuclear war without a catalytic military or political event. A situation of this sort is inherently more unstable than a situation where retaliatory forces are secure and where there is thus no incentive to preempt. The delicacy of the balance of first- and second-strike capabilities is therefore the source of this instability. If one side of a conflict determines that its retaliatory capability is insecure, the fear of a surprise attack may encourage a preemptive attack.

These concerns led the United States and the Soviet Union to the negotiating table several times during the Cold War in an attempt to find a way to prevent a dangerous situation from escalating out of control. A surprise attack conference was convened in 1958 to discuss this possibility, and the first in a series of "Hot Line Agreements" was signed in 1963, establishing a direct communications link between Washington and Moscow to ensure the ability to talk about a situation before undertaking military action. Confidence- and security-building measures also attempt to reduce the possibility of surprise attack.

—*Abe Denmark and Jeffrey A. Larsen*

See also: Accidental Nuclear War; First Strike; Hot Line Agreements; Preemptive Attack; Surprise Attack Conference

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RECONNAISSANCE SATELLITES

Intelligence-gathering or reconnaissance satellites (sometimes called spy satellites, or spysats) are an important means of collecting information about denied targets in another country, including weapons of mass destruction (WMD). There are two basic types of reconnaissance satellites: imaging systems that create "pictures" from sources such as infrared energy, visible light, ultraviolet light, or radar returns; and signals intelligence (SIGINT) systems that collect data from other portions of the electromagnetic spectrum such as voice communications, telemetry signals, or radar emissions. For most of the Cold War, spysats were a top-secret monopoly of the superpowers. They became increasingly important in later years as national technical means (NTM) of verification for arms control agreements (*see* National Technical Means). Today, spysats are becoming less expensive and more capable, and they are being used and operated by a growing number of states and commercial enterprises.

History and Background

Obtaining accurate intelligence data on the Soviet Union, especially on its nuclear weapons and ballistic missile programs, was a major challenge for the United States during the early Cold War period. This problem became particularly acute after the shock of the Soviet fission and fusion weapons tests, which began in 1949 and succeeded in producing a fusion device in 1955. In 1954, President Dwight D. Eisenhower commissioned a year-long study by influential scientists, the Technological Capabilities Panel (TCP), to address the evolving strategic environment and the threat of surprise attack. Following the July 1955 failure of its Open Skies proposal (a plan to allow the superpowers to overfly each other's territory with intelligence-gathering aircraft), the Eisenhower administration focused on space as a potential means of opening up the closed Soviet state. Creating a legal regime that would legitimize satellite overflight and intelligence gathering from space was the secret but overriding priority of America's first space policy, National Security Council (NSC) Memorandum 5520, promulgated in May 1955. This policy, some two and a half years before the Soviet Sputnik launch opened the space age, called for the United States to secretly develop spysats and openly develop scientific satellites to support the International Geophysical Year (IGY). The Eisenhower administration planned to orbit the IGY satellites first to establish a peaceful precedent for satellite overflight of sovereign space.

The TCP and NSC-5520 led directly to America's first high-tech spy programs: the high-flying U-2 spy plane and the WS-117L spysat system. The WS-117L program was begun in March 1955 and grew to encompass three types of intelligence gathering from space: photoreconnaissance via film return under the Corona program; photoreconnaissance via electro-optical signal return under the Samos program; and infrared early warning of ballistic missile launch under the Midas program. All of these programs were pushing the technology envelope and ran into significant delays and hurdles during the 1950s and 1960s. In August 1960, the first successful Corona photoreconnaissance mission returned film, which helped to dispel fears of a missile gap. But the first operational space-based infrared early-warning system was not established until the Defense Support Program (DSP) system was orbited in the late 1960s, and the electro-optical photoreconnaissance system was not deployed until the first launch of the KH-11 system in December 1976.

To maintain the veil of secrecy around the development and operation of spysats, the Eisenhower administration created the National Reconnaissance Office (NRO), an organization composed primarily of Central Intelligence Agency (CIA) and Department of Defense (air force and navy) personnel. The very existence of the NRO was an official state secret from its inception in August 1961 until its existence was declassified in September 1992. Under directives developed during the Kennedy administration, spysats and other types of military space activity were wrapped in deepest secrecy. The NRO quietly influenced U.S. space policy and programs during the Cold War. Examples of NRO influence included cancellation of the air force's Manned Orbiting Laboratory for intelligence gathering in favor of the NRO's KH-9 spysat; the evolution of the cross-range, payload, and cargo bay design for the space shuttle to accommodate future generation spysats; and NRO's success in the 1980s as the only organization allowed to build a backup launcher for the shuttle, the Complementary Expendable Launch Vehicle.

Satellites and Arms Control

Starting with the Vela Hotel nuclear detonation detection system, created to verify compliance with the 1963 Limited Test Ban Treaty, spysats became the linchpin in enabling strategic arms control between the superpowers—their most important role during the Cold War. Prior to the advent of increasingly capable space-based intelligence collection systems, U.S.-Soviet arms control negotiations had always broken down, often over the contentious issue of how compliance with agreements was to be verified. The United States had consistently called for on-site inspections (OSIs) to verify compliance, while the Soviet Union had rejected this approach as a violation of its national sovereignty. By the mid-1960s, however, U.S. negotiators had enough confidence in using spysats for verification that they were willing to forgo their previous insistence on OSIs. This change in policy was critical in bringing about the 1972 treaty resulting from the Strategic Arms Limitation Talks (SALT I), the first comprehensive arms control agreement between the superpowers. The Anti-Ballistic Missile (ABM) Treaty portion of SALT I contains the first euphemistic reference to highly secret spysats as "national technical means" of verification. There was also a subtle but critical link between what a spysat could "see" and arms control units of accounting. This linkage was an important factor in optimizing spysat improvements for the NTM mission during the latter half of the Cold War.

Satellites in the Post–Cold War Era

Following the end of the Cold War, the United States reordered its spysat priorities and policies. With recognition of the significant force-enhancement capabilities of space systems during Operation Desert Storm (the "first space war"), the United States moved to make the NRO's imagery more quickly and openly available to operational commanders and units on the battlefield. This shift has enabled the reconnaissance, precision-strike revolution in military affairs that has characterized the new American way of war.

Changes in the commercial remote sensing sector are perhaps even more significant. Under the Land Remote Sensing Policy Act of 1992 and Presidential Decision Directive (PDD) 23 of March 1994, the United States now seeks to create incentives for the development of a commercial high-resolution remote sensing industry that will be dominated by U.S. firms. The National Imagery and Mapping Agency (NIMA) was created in 1996, in part to support this new policy and to facilitate dissemination of high-resolution commercial remote-sensing data to users throughout the U.S. government. Reflecting the availability of high-quality commercial imagery, the director of Central Intelligence recently ordered that commercial systems rather than government spysats become the primary data source for all U.S. mapping efforts.

It is unclear how more and increasingly capable spysats used and operated by a growing number of state and nonstate actors will impact privacy, transparency, and the proliferation of weapons of mass destruction. It is likely, however, that these systems will continue to have a significant effect on global security and play a growing role in international security and commerce in the years ahead.

—Peter Hays

See also: Early Warning; Open Skies; Outer Space Treaty; Verification

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RED MERCURY

The substance known as "red mercury," purportedly a mystery ingredient in Soviet pure fusion weapons, gained both U.S. congressional and worldwide media attention in the wake of the 1991 collapse of the Soviet Union when it began appearing on the nuclear materials black market. The red mercury furor began over reports that the Soviet Union had perfected a pure fusion nuclear warhead, which reportedly relied on heavy hydrogen—deuterium and lithium isotopes—as its fuel.

It is said that under the proper heat and pressure, the lithium and deuterium isotopes fuse, releasing high-energy neutrons that kill living matter in their path. Identified by traffickers with the composition $Hg_2SB_2O_7$ (that is, a combination of mercury, sulphur, boron, and oxygen), red mercury has since been surmised to be the Russian code name for lithium deuteride, Li_6D, a legitimate component in thermonuclear weapon production, or the heavy metal osmium.

Though there are some detractors who insist that red mercury is legitimate, much of the nuclear scientific community has stepped forward to discredit it as an important component in pure fusion weaponry. Instead, it is generally accepted that red mercury was touted by intelligence organizations or criminals as a weapons material to hoodwink terrorists and states with nuclear ambitions. Reports of it appearing on the nuclear black market have become less frequent in recent years.

—Jennifer Lasecki

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REENTRY VEHICLES

A reentry vehicle (RV) is a casing that protects a missile payload during descent through the Earth's atmosphere. At intercontinental distances, reentry velocities can reach Mach 20 (that is, twenty times the speed of sound), creating enough atmospheric friction to destroy an unprotected object. Reentry vehicles are separate from the payloads they protect. Their design is complicated by the need to balance weight, drag, and thermal protection without compromising accuracy.

When long-range ballistic missiles were conceived in the 1940s, there was no way to deliver a payload safely back to Earth. The first solutions in the 1950s relied on blunt shapes to rapidly attenuate speed and heating. Soviet designers used spherical RVs coated with heavy metals. Chinese ballistic missiles appear to rely on a similar approach today. U.S. engineers pioneered radical shapes with low ballistic coefficients, or beta ratios. These "heat sink" designs—shaped like a backwards cone or an inverted bell—dissipate velocity through shock-wave propagation at high altitudes where heating is less extreme. High drag and low speed also had unwanted effects, reducing payload capabilities and degrading accuracy.

The optimal solution to the beta-dilemma of maximizing both reentry cooling and accuracy was perfected in the United States in the 1960s through development of ablative coatings. These plastic-based materials burn evenly from narrow cone-shapes during high-speed reentry. This enables the attenuation of heating without compromising accuracy. No less important was development of small nuclear warheads adapted to these shapes. The first fully successful ablative, high-beta design was the Mark-12 reentry vehicle for the Minuteman III intercontinental ballistic missile. The Mk-12, which became operational in 1970, was the basis for all subsequent American nuclear reentry vehicles. By the late 1970s, a similar approach to the reentry problem was perfected in the Soviet Union.

—*Aaron Karp*

See also: Ballistic Missiles; Downloading; Intercontinental Ballistic Missiles; Maneuvering Reentry Vehicle; Multiple Independently Targetable Reentry Vehicle

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RELIABILITY

The term "reliability" is often used to describe the likelihood that nuclear weapons and associated delivery systems will function according to expectations and that personnel charged with maintaining and operating nuclear-equipped forces will carry out their duties according to instructions and accepted procedures.

Reliability is an important factor in nuclear war plans, and analysts have devised specific formulas for calculating the reliability of various weapon systems. For example, the probability of killing a mobile missile launcher can be calculated using the equation $PK = r(Ai/Aii)$, where PK equals the probability of destroying the mobile launcher ("probability of kill"); *r* equals the reliability of the attacking weapon (generally assumed to be about 0.9 for a U.S. intercontinental ballistic missile); Ai equals the area over which a warhead can generate lethal overpressure (generally assumed to be about 5 pounds per square inch); and Aii equals the area of uncertainty about the location of the mobile launcher (*see* Accuracy; Intercontinental Ballistic Missiles; Nuclear Weapons Effects; Yield).

The U.S. Personnel Readiness Program (PRP) is intended to guarantee that only emotionally stable, physically capable, dedicated professionals are responsible for the maintenance or delivery of nuclear weapons. Individuals who are part of the PRP program are subject to continuous evaluation in terms of their reliability, trustworthiness, conduct, and behavior. PRP also evaluates the medical condition of all individuals who come into contact with nuclear weapons, especially those who are charged with providing security to nuclear storage facilities. This evaluation includes random drug testing.

—*James J. Wirtz*

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REPROCESSING

Reprocessing is the industrial process of removing plutonium from spent nuclear reactor fuel. When uranium fuel rods are put into a reactor and irradiated, they are described as spent fuel. Irradiated fuel has to be removed from a reactor's core when only about 3 percent of its uranium has been burned, if plutonium recovery is the goal. Weapons-grade plutonium is produced when special rods are used to convert uranium 238 (U-238) into plutonium in a so-called target. Irradiated fuel and special weapons targets from production or power reactors are chemically processed for the separation and recovery of fissile uranium and plutonium. Reprocessing plants consist of heavy reinforced-concrete structures to provide shielding against the intense gamma radiation produced by the decay of short-lived isotopes in the spent fuel rods. The most challenging technical component of a reprocessing plant is the separation system (consisting of mixers/settlers, extracted columns, or centrifugal contractors). Flow rates through the reprocessing plant must be monitored precisely, the chemistry must be exact, and any accumulation of radioactive products large enough to reach critical mass leading to massive radioactive release must be prevented (*see* Criticality and Critical Mass; Isotopes).

Radioactive isotopes also can be recovered that are used for special radio-chemistry purposes. These include plutonium 238, strontium 90, cesium 137, and krypton 85 as well as the by-product transuranic elements neptunium, americium, curium, and californium. Spent fuel from reactors is stored in water ponds from six months to four years to allow for a decrease in radioactivity. This permits short-lived, highly radioactive isotopes to decay. Reprocessing involves removing the metal casing from around the fuel (decladding) and dissolving the fuel in hot concentrated nitric acid. The most common method for chemically processing irradiated fuel is the PUREX (plutonium-uranium extraction) process. Two early methods for separating plutonium—the bismuth phosphate process and the Redox process—are important historically but no longer in use.

Early Methods

The bismuth phosphate process was developed during World War II at the Metallurgical Laboratory at the University of Chicago. It was used to separate the first plutonium in 1942 that had been produced in a cyclotron. The bismuth phosphate process was then developed on an engineering scale and demonstrated at the Oak Ridge, Tennessee, X-10 plant in 1944. It was put into full operation at Hanford, Washington, to separate plutonium from production fuel. The bismuth phosphate process recovered plutonium but was unable to separate and recover any uranium from the irradiated fuel. This was a serious disadvantage, since it meant that half of the reusable isotopes from the fuel rods were wasted. After the fuel elements were dissolved in nitric acid, bismuth nitrate and sodium phosphate were added to the solution, and plutonium was then removed. This method created a large amount of hot radioactive waste that is still stored at Hanford.

The Redox process was the first counter-current process used in the United States for large-scale extraction of plutonium and uranium from irradiated fuel. Unlike the bismuth phosphate process, it could operate continuously rather than in batches (when the reactor fuel was cool and ready for processing). In the Redox process, plutonium, uranium, and fission products were recovered and discharged in separate streams. After spent fuel was dissolved in nitric acid, an aqueous solution of uranyl nitrate, plutonyl nitrate, and fission product nitrates remained. This was followed by the introduction of an organic solvent, hexone, in which the uranyl and plutonyl nitrates concentrated. Fission product nitrates were left in the liquid phase. In three subsequent steps, the fission products were first removed and the plutonium was then chemically reduced and removed as plutonium nitrate. The bismuth phosphate process was in use from 1944 until 1956, the Redox process from 1956 until 1968. The Redox process recovered both plutonium and uranium and thus was a more efficient means of producing weapons fuel.

The PUREX Process

In the PUREX process, the irradiated fuel is dissolved in an aqueous solution of nitric acid, and the desired chemical elements are extracted in a series of steps with an organic solvent. Fuel rod elements are chopped into smaller pieces to expose the fuel material for subsequent acid leaching. Fuel cladding is frequently not soluble in nitric acid, so the fuel rod itself must be opened to allow chemicals to reach the fuel inside. Developed in 1954, the PUREX process was used at both Hanford and the Savannah River, South Carolina, production sites. The aqueous solution contains uranyl nitrate, plutonium nitrate, and other fission product nitrates. The liquid solution is then fed into a solution extraction contractor.

The uranium and plutonium are separated from each other in further extraction steps. Plutonium is then converted to a solid oxide or metal form before it is shipped or stored. Uranium is generally converted to uranium trioxide.

All nuclear weapons states have reprocessing facilities. The ones in the United States are currently in a stand-by mode. Russian plants switched to the production of civilian reactor fuel after the end of the Cold War. In 2003, only the United Kingdom (Sellafield) and France (Cape La Hague) were reprocessing commercial reactor fuel. Japan ships its fuel to France for reprocessing. Russia had a large nuclear power and reprocessing infrastructure, but today little reprocessing goes on in Russia owing to lack of funding. Hopes in the 1970s of having plutonium, mixed oxide (uranium and plutonium mixed fuel rods), or fast-breeder (plutonium-producing) reactors on line to produce power have given way to environmental and proliferation fears. Civilian nuclear power reactors produce plutonium even if natural uranium is burned; thus, reprocessing and proliferation concerns go hand in hand.

Reprocessing has produced vast amounts of radioactive waste for fifty years. Everything that comes into contact with spent fuel is radioactive and must be disposed of in special storage sites. Some items will be radioactive for tens of thousands of years. The discharges by these plants into the atmosphere, water, and ground are frequently cited by Greenpeace in its reports about the most contaminated places on earth.

—Gilles Van Nederveen

See also: Plutonium; Uranium

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RESEARCH REACTORS

Research reactors are nuclear reactors designed to generate neutrons for investigational and experimental purposes. These reactors often are not used to generate and supply power commercially. Research reactor designs vary widely and have a range of uses.

Many research reactors are used for educational purposes and are located at academic institutions throughout the world. Other research reactors are designed for the production of isotopes used in medical, industrial, scientific, and research applications. Research reactors also may be used for materials testing and general scientific experimentation

The first research reactor was designed and built by Enrico Fermi at Stagg Field Stadium, Chicago, on December 2, 1942. Fermi used this reactor to achieve the first nuclear chain reaction. The number of research reactors multiplied significantly in the 1960s and early 1970s. Many of these reactors are still in use today, with two-thirds of the research reactors in the world being more than thirty years old.

Research reactors are generally smaller than nuclear reactors designed to generate electricity, and they generate significantly less or essentially no electric power. The enrichment level of the fuel for research reactors is generally higher than for nuclear power reactors, about 20 to 95 percent uranium 235–enriched fuel compared to approximately 3 to 5 percent uranium 235–enriched fuel.

There are approximately 36 research reactors licensed in the United States, located in 23 states, and approximately 283 additional research reactors in 56 countries throughout the world.

—Don Gillich

See also: Low Enriched Uranium; Radiation; Reactor Operations

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RESTRICTED DATA (RD)

"Restricted Data" (RD) is a classification level for all U.S. information related to the design, manufacture, or use of nuclear weapons and the fissionable material used in nuclear devices. Examples of RD include information about the design of thermonuclear weapons or their unique components, including specific information about the relative placement of weapons components and their role in initiating and sustaining a thermonuclear reaction. RD also covers information about the construction and operation of the nonnuclear portions of a nuclear weapon, consisting of the high-explosive system with its detonators and firing unit, "pit" system, and nuclear initiating system. Information about design features or vulnerabilities of nuclear weapons that might permit their unauthorized detonation also is considered to be Restricted Data (*see* Fission Weapons; Pit; Thermonuclear Bombs).

Under the 1954 Atomic Energy Act, the secretary of energy is responsible for issuing orders, guides, and manuals concerning the protection of RD. RD includes several subcategories, ranging from "Top Secret" to "Confidential." Information held at the level Confidential RD, for instance, includes the amount of high explosive used in a nuclear weapon.

The term "Formerly Restricted Data" (FRD) refers to information that is no longer considered to be RD but remains classified. Special restrictions apply to the release of FRD to foreign nationals. Individuals who are given clearances to view RD go through a lengthy screening process and background check to determine that they will be reliable custodians of this highly sensitive information.

—James J. Wirtz

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REVIEW CONFERENCE

See Arms Control

REYKJAVIK SUMMIT

The Reykjavik Summit, held in Iceland October 11–12, 1986, was initially billed as a meeting to reinvigorate superpower arms control. President Ronald Reagan's Strategic Defense Initiative (SDI) had called into question the "offense dominance" concept that had served as the basis of arms control since the early 1970s. In addition, the Soviets sought to keep this new SDI technology in the laboratory. An earlier summit in Geneva in 1985 made little progress in terms of reaching a compromise on how strategic defenses might be integrated into the existing arms control regime.

At the Icelandic capital of Reykjavik, face-to-face negotiations took place between Reagan and Soviet general secretary Mikhail Gorbachev. Gorbachev proposed a 50 percent reduction in all strategic weapons, the total elimination of Soviet and U.S. intermediate-range missiles in Europe, and strict compliance with the 1972 Anti-Ballistic Missile (ABM) Treaty, which would have prevented the SDI program from deploying a missile defense system for at least ten years. Gorbachev agreed to the U.S. demand for on-site inspections and dropped the demand to count British and French missiles as part of the U.S. arsenal. U.S. officials countered with specific proposals to reduce existing nuclear arsenals on both sides (6,000 nuclear warheads and 1,600 strategic nuclear delivery vehicles for each side). Although the original summit was focused on Europe, the Soviets also agreed to limit medium-range missile deployments in Asia to 100 warheads and to recognize human rights as a legitimate point of future superpower negotiations.

The final meeting started with a Soviet demand that the United States make concessions on SDI. Reagan offered only to keep SDI in the lab for ten years and made the fantastic offer to eliminate all intercontinental ballistic missiles within a decade. Although Gorbachev appeared willing to consider banning ballistic missiles, he could not allow the United States to develop space-based missile defenses. In the end, no agreement was reached, and the summit was considered by many to be a failure.

The Reykjavik Summit, however, demonstrated that both Soviet and U.S. officials were willing to address fundamental Cold War assumptions and explore innovative ways to reduce political tension and armaments. Several initiatives discussed at Reykjavik actually served as the basis for eventual treaties. In 1987, for example, Soviet and U.S. officials agreed to ban an entire class of nuclear delivery systems when they signed the Intermediate-Range Nuclear Forces (INF) Treaty. According to one State Department official, this was the turning point in the Cold War, the moment when the superpowers stopped building up nuclear weapons. And in 1991, both sides signed the Strategic Arms Reduction

Treaty (START I), which used the Reykjavik numbers as the goal for strategic reductions.

—*Frannie Edwards and James J. Wirtz*

See also: Anti-Ballistic Missile (ABM) Treaty; Arms Control; Cold War; Intermediate-Range Nuclear Forces (INF) Treaty; Strategic Arms Reduction Treaty (START I); Strategic Defense Initiative (SDI)

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RIDE OUT

A military force is said to have the capability to "ride out" an attack if it can survive the attack and continue to operate in its aftermath. Officials who make the ability to ride out a nuclear attack a matter of policy must procure and deploy nuclear forces accordingly. Forces that can ride out an attack increase crisis stability because they reduce the incentives for both sides in a deterrence relationship to use nuclear weapons first in a crisis.

The survivability of military forces and command and control operations is crucial to the success of deterrence because it is the threat of retaliation under all circumstances that reduces the likelihood of aggression. Survivable forces also are not dependent on strategic or tactical warning to ride out an attack; in the event of human or technical error, they can still undertake their retaliatory mission.

Launch-on-warning or launch-under-attack doctrines can be adopted if the survivability of retaliatory forces is in doubt. These doctrines are generally considered to be inferior to forces and doctrines that create conditions to ride out attack because they place a heavy burden on policymakers to make split-second decisions at moments of deep national crisis. Launch on warning also requires policymakers to use nuclear weapons before undisputable evidence is available that they are under attack, namely nuclear detonations on their own soil. Developing a ride-out capability, however, is both technically and financially challenging. New nuclear weapons states often lack the resources or even geography needed to create a survivable nuclear force.

—*James J. Wirtz*

See also: Crisis Stability; Deterrence; Launch on Warning/Launch under Attack

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ROCKY FLATS, COLORADO

Rocky Flats is a 10-square-mile site just northwest of Denver, Colorado, where, for nearly forty years, the U.S. government manufactured nuclear weapons components, specializing in plutonium pits, or nuclear triggers (*see* Pit). Production has now ceased at the site and a cleanup is under way. Rocky Flats is one of the most contaminated tracts of land in the United States.

The plant was set up in 1952, originally to make plutonium spheres, which served as triggers for hydrogen bombs. Plutonium from old nuclear warheads and weapons parts machined from beryllium also were recycled at the Rocky Flats facility. Plutonium and beryllium are just some of the radiological and chemically toxic substances that were used at the plant. Several accidents took place at the facility, including serious fires in 1957 and 1969, which vented plutonium into the atmosphere. Additionally, poor storage techniques allowed radioactive and other toxic substances to leak into the soil and ultimately into drinking-water reservoirs.

The fact that incidents kept reoccurring and that safety standards seemed so lax at a plant only 16 miles from downtown Denver led to a raid by the Federal Bureau of Investigation (FBI) in 1989. The plant immediately ceased its production of plutonium. The fact that the plant was shut down suddenly, rather than gradually over many years, created problems when it came to disposing contaminated materials and equipment. Great efforts have been made since 1989 to clean up the facility, including further removal of topsoil and the transfer of waste plutonium to the Savannah River, South Carolina, site. Today, there are still some 10,250 people working to decontaminate Rocky Flats.

—*Rod Thornton*

See also: Savannah River Site

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ROENTGEN EQUIVALENT MAN (REM)

Roentgen equivalent man (rem) is a unit of measurement of the absorbed dose of ionizing radiation deposited in body tissue. One rem is the dose from any type of radiation that corresponds to the exposure to 1 roentgen of radiation from X-ray or gamma radiation.

The "rad" (for "radiation absorbed dose") is a measure of absorbed dose from any kind of radiation in any medium in terms of fundamental energy units. "Roentgen" is also a unit of absorbed dose but is used only in relation to X-ray and gamma radiation (*see* Radiation).

Rem takes into account the biological effects of different kinds of radiation. The numerical value of an exposure or dose in roentgens is approximately the same as the value given in rems or rads. Simply stated, rem puts all kinds of radiation on an equal level. One rem of gamma radiation plus 1 rem of alpha radiation equals 2 rem of absorbed radiation.

"Absorbed dose" is radiation actually absorbed into some material, such as the human body. The term should not be confused with "exposure dose," which is radiation available to be absorbed.

—Jeffrey A. Adams

See also: Radiation Absorbed Dose (Rad)

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RUMSFELD COMMISSION

On July 15, 1998, the Rumsfeld Commission released its conclusion that several countries hostile to the United States—particularly Iran, North Korea, and Iraq—would be able to attack the United States with ballistic missiles within five to ten years of a decision to acquire such technology. The commission predicted that the United States might have little or no warning before an enemy state acquired long-range ballistic missiles because it was difficult to gauge how outside financial or technical aid could accelerate indigenous weapons programs. Led by former (and future) secretary of defense Donald Rumsfeld, the commission was created by Republican members of Congress interested in challenging existing intelligence estimates of missile threats and reshaping the debate on pursuing a national missile defense (NMD) system. The group was not given a mandate to suggest a policy to address the threats it identified, but the report influenced congressional debates, helped reshape the timetable for national missile defense under President Bill Clinton, and influenced George W. Bush's administration in its drive to deploy an antiballistic missile system to defend the United States.

The commission's report directly challenged the conclusions of the Central Intelligence Agency (CIA) in its 1995 "National Intelligence Estimate" (NIE). According to CIA projections, no rising power would have ballistic missiles capable of threatening the United States for fifteen years. The NIE also argued that countries pursuing missiles would have to rely on domestic resources, since foreign assistance in the field remained relatively rare. Therefore, the intelligence community would have several years' warning of any successful missile development. These views helped support Clinton's plan to spend three years developing a defense that could be deployed within another three years if a threat emerged.

The Rumsfeld Commission, and supporters of NMD, disagreed with the NIE on each point. The shorter timetable suggested by the commission grabbed headlines. It was based on a new methodology in assessing threats that put more focus on possibilities for future development than on known past actions. Additionally, the commission argued, new states would be able to acquire weapons more quickly and more secretively than other states had done in the past because they would be less concerned with high standards of accuracy and safety. Furthermore, they argued that an international market of missile technology was emerging, creating possibilities to acquire technology from Russia, China, and Pakistan. Given the intense secrecy surrounding clandestine weapons programs and the possibility for rapid acquisition of materials and technology, the commission concluded that the United States might have little or no warning before an enemy acquired missiles.

Critics of the commission's report questioned its methodology, some of its statements, and the way the report was used in the overall NMD debate. The commission centered its methodology on possibilities, and usually worst-case scenarios for possibilities. Critics charged that this left out calculation of the probability of actual actions. For example, although Iran may be able to get weapons quickly, the threat is less immediate if political or other calculations discourage nuclear weapons or missile acquisition in the first place. The commission also focused exclusively on ballistic missile threats, which ignored the possibly more immediate threats from cruise missiles or terrorist attacks. Critics also believed that the Rumsfeld report overstated both the reliability of missiles, by assuming that all launches would be successful, and the extent of ongoing international technology sales. Finally, within the NMD debate there have always been three central questions: (1) Is a defense technically possible? (2) Does a threat exist to justify a defense? and (3) Would a defense bring too many negative ramifications? The Rumsfeld report focused only on the second question, but critics believed its dramatic language shifted focus away from the possible negative implications of missile defense by creating the impression that only technical questions remained to be solved.

—John W. Dietrich

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RUSSIAN NUCLEAR FORCES AND DOCTRINE

After the detonation of the first Soviet atomic device in 1949 and the Soviet hydrogen (fusion) device in 1953, the Soviet military went about acquiring the world's largest arsenal of nuclear weapons. In addition, the Soviet military introduced ballistic and cruise missiles, satellites, computers, and other automation devices into their arsenal. Soviet military writings since the late 1950s asserted that there had been a revolution created by the introduction of nuclear weapons and long-range, high-speed delivery systems. In Soviet defense publications, these inventions were referred to as a "revolution in military affairs." But of all these developments, nuclear weapons most affected Soviet strategy. Soviet writers believed that nuclear weapons altered the nature and methods of armed struggle on the strategic level because they could accomplish the military's strategic tasks without operational art or tactics. According to Soviet military theory, this revolution fundamentally altered the character of any future war by increasing the importance of the opening moments of a conflict. It changed the relationship between strategic and nonstrategic forces. It also created the requirements for a new force posture, geared to a new tempo, scope, and scale of nuclear operations at the continental and intercontinental ranges. The heart of this force posture and associated doctrine was developed in the 1960s and recorded in Marshal Vasily Sokolovsky's three editions of *Military Strategy* (published in 1962, 1963, and 1968) (*see* Military Technical Revolution [Revolution in Military Affairs]).

In the Soviet Union, where strategy is considered a science and the special province of the military, nuclear weapons were not held to be "absolute." The idea of mutual deterrence was never accepted. Soviet theorists rejected the idea that technology determines strategy and instead adapted nuclear weapons to their traditional Clausewitzian view of war as an extension of politics (based on the well-known military concepts of Karl von Clausewitz [1780–1831]). Transition to a nuclear strategy began in the mid-1950s, when Soviet military thinkers recognized the importance of surprise and the first stages of a war and sought to use nuclear strikes to determine the course and outcome of battle. This concept stressed the importance of preemption—striking before the enemy could strike the Soviet heartland or other socialist countries. The increased mobility of the Red Army, the traditional battlefield force, and the power of nuclear weapons allowed the Soviets to explore deep offensive operations. They concluded that their political objectives and their views on war dictated a force posture that would enable them to take the offensive from the outset of a war, thereby setting the conditions in the so-called initial period, which would determine the course and outcome of the conflict. Their strategy also held out the promise that some level of damage limitation to the Soviet Union could be achieved if hostile offensive forces could be destroyed before they could be employed. As a result, the Soviets required reliable forces able to destroy distant targets quickly. Their ballistic missiles possessed a unique combination of range, speed, accuracy, reliability, controllability, and in-flight invulnerability. This combination of attributes made intercontinental ballistic missiles (ICBMs) the ideal weapon to fulfill their military strategy (*see* Preemptive Attack).

The first formal Soviet doctrine for the nuclear age was that of Nikita Khrushchev's "one-variant war." According to this view, a future war would be extremely short and swift and would have an initial period of hostilities that would decide the course and outcome of the entire war. Consequently, Soviet nuclear strategy emphasized mass nuclear strikes and dismissed Western notions of escalation thresholds or limitations to the character and size of nuclear operations. These strikes were best characterized as countervalue, since counterforce targeting required accuracies in missile systems that did not exist until the early 1970s. Because an advantage would accrue to the side that struck first, and because Soviet strategic offensive forces in the 1960s were relatively unreliable, inflexible, and vulnerable, Soviet nuclear strategy focused on the rapid detection of enemy preparations for war (*see* Counterforce Targeting; Countervalue Targeting).

The drawbacks to the one-variant war concept soon became apparent to Soviet political and military leaders. The threat of massive retaliation served only to deter direct, massive attacks on the Soviet homeland; it was of doubtful utility in responding to less-than-all-out attacks. Furthermore, the Khrushchevian strategy offered no prospect for Soviet survival in the event of a general nuclear war. Soviet strategists realized that a more robust strategic force posture was required to meet Soviet political and military options. Although the means for preemptive counterforce operations were unavailable in the 1960s, the Soviets set about to create the desired force structure.

By the late 1970s, the Soviets began to acknowledge that even successful preemption was unlikely to determine the outcome of a nuclear war. Initial strikes by land-based ballistic missiles, it was said, would have a decisive impact on the initiation and course of hostilities but could not determine the outcome. This was the signal that the Soviets believed that more than a single massive nuclear salvo was required for victory. Such formulations also gave an increasing role to other Soviet nuclear forces, the submarine-launched missiles and bombers, in determining the course and outcome. The targeting objectives for the fleet ballistic submarine force suggest that although the use of submarine-launched ballistic missiles (SLBMs) in initial strikes was contemplated, the majority of the SLBMs at sea would be withheld to conduct follow-on strikes that could determine the overall course of the war.

Russian nuclear missile silo opened for inspection by Strategic Rocket Forces at a site near Saratov, November 1994. (km/str/Reuters/Corbis)

Discussions of the prospects for victory in a strategic nuclear war appeared to turn on judgments regarding the ability of Soviet offensive and defensive forces to avoid suffering a preemptive attack and to destroy the opponent's nuclear forces in order to limit damage to the Soviet homeland. Despite the attainment of strategic parity in the mid seventies, the continued production of nuclear weapons by itself was seen as providing no enduring advantages to the Soviet Union. Chief of General Staff Marshal Nikolay Ogarkov made a number of provocative statements between 1982 and 1985 about the paradox existing between the continued acquisition of nuclear weapons and their inability to achieve decisive victories against opponents of the Soviet Union.

Stalin and Nuclear Inferiority

Joseph Stalin saw the turmoil at the end of World War II as an opportunity for expanding the Communist empire. At that time, however, he lacked a nuclear capability and therefore attempted to exploit low-risk situations. He was not prepared to risk a full-scale conflict with a United States that could use nuclear weapons with impunity. Nuclear weapons, strategy, and employment were taboo subjects while Stalin was in power.

Khrushchev and Strategic Capability

By 1955, Nikita Khrushchev had emerged as the major figure of the Soviet leadership. The U.S.S.R. was building a strategic nuclear arsenal, which Khrushchev was prepared to brandish in confronting Western powers. Khrushchev made it clear that he considered the nuclear-tipped strategic missile to be the basis of Soviet military power. In his statement to the Supreme Soviet in January 1960, he proposed reducing the armed forces by 1.2 million men and disposing of military aviation and surface ships. In its place, the Strategic Rocket Forces (SRF) were to become the premier Soviet armed service. Its missiles could strike at theater and intercontinental ranges and give the Soviets leverage in the Cold War. The lack of Western intelligence made it easy for Khrushchev to exaggerate the size and capability of the Soviet nuclear arsenal as a means of bullying, bluffing, and boasting his way through crises.

Although Khrushchev publicly stated that deterrence was the goal of Soviet defense policy, Soviet military planners tended to believe that preemption remained a viable strategy if nuclear war with the West appeared inevitable. By delivering a preemptive strike against the opponent's offensive systems and countervalue targets, Soviet planners believed they could blunt the capability and the will of the opponent to retaliate. Soviet planners also believed that the battlefield use of nuclear weapons would allow them to seize the initiative and win decisively.

During the Khrushchev era, the Soviet Strategic Rocket Forces deployed first-generation liquid-fueled missile systems on aboveground launchers. These launch complexes could not withstand a nuclear strike. Between 1955 and 1961, the Soviets deployed the intermediate-range SS-4 and SS-5 along their western border. The SS-7 ICBM also was deployed at about the same time. The SS-8 ICBM, a silo-based system that entered service in the Strategic Rocket Forces in the early 1960s, increased the survivability of the Soviets' land-based missile force. These first-generation systems had low combat readiness. Because the liquid rocket fuels used at the time were so corrosive, the missiles could only be kept fueled for thirty days. Time to prepare missiles varied from a few minutes to hours, depending on the complexity of the missile being readied to fire (*see* Cold War; Intercontinental Ballistic Missiles).

Brezhnev and Nuclear Parity

During the Leonid Brezhnev era, the Soviet Union achieved strategic "parity"—a rough equivalence in strategic nuclear capability—with the United States (*see* Parity). Second-generation Soviet systems, created in the second half of the 1960s, included permanently fueled missiles with a very high level of readiness. This time period also saw the use of hardened single silo launchers and command centers in the Soviet Union. The use of single silo launchers in a wide crescent, stretching from the Ukraine into Kazakhstan along the trans-Siberian railroad, significantly improved the survivability of the missile force. Second-generation solid-fuel Soviet ballistic missiles could now be kept on a high state of alert, increasing the survivability of the Strategic Rocket Forces. The SS-11 became the main component of the land-based nuclear deterrent, with a force of 990 deployed missiles. The SS-9, a heavy ICBM capable of lofting a 10-megaton warhead against U.S. ICBM complexes, was also deployed. Eventually the U.S.S.R. deployed 308 of these heavy ICBMs.

U.S.-Soviet arms control negotiations during the Brezhnev era often highlighted the fact that Soviet planners failed to accept the situation of mutual assured destruction (MAD) as an unalterable fact. Soviet military writings, political statements, and force structure suggested to many Western observers that Soviet planners believed they could benefit from the early and massive use of nuclear weapons in any serious conflict with the West. In the 1970s, a Soviet conventional and theater nuclear force buildup was accompanied by redoubled civil defense measures and preemptive nuclear doctrines. Observers suggested that the Soviets had adopted a policy of "deterrence by denial," that is, their notion of deterrence was based on the ability to fight and win a nuclear war. Soviet officials, however, probably never believed that they could actually use nuclear war as an instrument of policy or that victory in an all-out nuclear war was really within their reach (*see* Deterrence; Mutual Assured Destruction).

By the early 1980s, the Soviets began deploying a third generation of strategic systems that bolstered their nuclear warfighting capabilities. The SS-18 emerged to replace the SS-9, and the SS-17 and SS-19 replaced the SS-11 force. Soviet ICBMs also were equipped with multiple independently targetable reentry vehicles (MIRVs), which increased the overall prompt hard-target kill capability of the Soviet nuclear arsenal. The SS-20, a MIRVed, road-mobile intermediate-range ballistic missile (IRBM), and the Tu-22M Backfire bomber also were deployed during this period and greatly increased the ability of Soviet forces to hold theater targets at risk with nuclear weapons.

Soviet Strategy at the End of the Cold War

Fourth-generation Soviet strategic forces were entering service by 1991, just as the Cold War was ending. Soviet planners had begun to increase the survivability of their land-based missile force by deploying rail-mobile (SS-24) and land-mobile (SS-25) ICBMs. As the range of Soviet submarine-launched ballistic missiles increased, they began to deploy their fleet ballistic missile submarines in "bastions" operating close to Soviet bases. These were heavily defended by the Soviet Navy and land-based aviation. The culmination of Soviet ballistic missile submarine development was the Typhoon class, which had a unique hull configuration and was equipped with a new MIRVed missile. Each Typhoon could carry up to 200 nuclear warheads. The Soviets also began to produce an intercontinental jet bomber, the Blackjack. But by 1989, only sixteen of these expensive bombers had been built.

Russian Nuclear Doctrine Today

As the Soviet empire slipped away, Russian nuclear force modernization slowed to a snail's pace as Russian officials, in conjunction with their U.S. counterparts, greatly reduced the size of their strategic nuclear arsenal. Although the Russians have stated that they still contemplate the first use of nuclear weapons in response to serious strategic threats, economic realities have forced them to make significant reductions in their nuclear arsenal.

In the fifty years from the Soviet acquisition of the atomic bomb (1949) to the beginning of the end of the Soviet empire (1989), Soviet nuclear doctrine was transformed from a quest to achieve victory in nuclear war to a gradual acceptance of the fact that a large-scale nuclear exchange between the United States and Russia would produce mutual assured destruction.

—Gilles Van Nederveen
and James J. Wirtz

See also: Arms Race; Bombers, Russian and Chinese Nuclear-Capable; Détente; Nuclear Warhead Storage and Transportation Security (Russia); Strategic Forces; Submarines, Nuclear-Powered Ballistic Missile; Submarine-Launched Ballistic Missiles; United States Nuclear Forces and Doctrine

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SAFEGUARD ANTIBALLISTIC MISSILE (ABM) SYSTEM

Safeguard was a U.S. ballistic missile defense (BMD) system deployed for a short time in 1975. In 1969, President Richard M. Nixon announced plans for the system, basing it on earlier U.S. BMD proposals such as the Sentinel and Nike-Zeus programs. Nixon changed the mission of U.S. missile defense, however, from national protection of the general public to providing cover for U.S. land-based strategic missiles at a few crucial military sites. Safeguard consisted of detection radar and long- and short-range antiballistic (ABM) missiles equipped with nuclear warheads designed to intercept incoming missiles or fractional orbital bombardment systems (FOBS).

Safeguard became operational on October 1, 1975, but on the next day the U.S. House of Representatives voted to shut down the program. Opponents of the system argued that the development of Soviet multiple independently targetable reentry vehicles (MIRVs) meant that Safeguard could not handle an overwhelming attack. In addition, several other technical problems reduced its effectiveness. For example, simulations showed that tracking radars would fail after the interceptor detonated its nuclear warhead.

Political issues, both domestic and international, played heavily in the Safeguard debate. The U.S. Senate approved Phase I of the program on a 50–50 vote, with Vice President Spiro T. Agnew casting the tie-breaking ballot. Supporters maintained that in addition to its defensive value Safeguard would create a bargaining chip in upcoming arms control talks with the Soviet Union. Safeguard designers originally intended the system to be deployed at twelve sites, but in negotiations with the Soviet Union over the Anti-Ballistic Missile Treaty, negotiators reduced the number of sites to two: Grand Forks Air Force Base, North Dakota, and Washington, D.C. Following an amendment to the ABM Treaty in 1974 limiting each side to just one ABM site, Grand Forks, home to 150 Minuteman intercontinental ballistic missiles (ICBMs), emerged as the sole location of a U.S. BMD system.

With Safeguard's detection equipment working in conjunction with a nearby radar installation, the system could detect Soviet ICBMs as they passed over the North Pole, thereby giving operators just a few minutes to react to an incoming missile attack. The U.S. response consisted of two types of missiles: the long-range Spartan and the short-range Sprint, both armed with nuclear warheads. Designers created Safeguard to provide a layered defense. The Spartan ABMs would first attack incoming clusters of warheads, booster rockets, and decoys, and then Sprint ABMs would intercept surviving warheads as they penetrated the atmosphere.

Opponents of missile defenses, however, argued that with only 100 interceptors stationed in North Dakota, the Soviet Union could easily overpower the defense. Congressional faith in the project began to diminish. The Senate initially resisted efforts to terminate the program, but following revelations that the Pentagon had come to the same conclusions about Safeguard's lack of effectiveness a year earlier, senators agreed to end operational funding. The army then began dismantling Safeguard, finishing the task in February 1976. The entire program cost was $5 billion (some $25 billion in current dollars).

U.S. BMD programs have since rejected Safeguard's method of using nuclear weapons to destroy incoming missiles. For moral and technical reasons, the United States now pursues other BMD options, including hit-to-kill kinetic-energy devices and directed-energy lasers.

—John Spykerman

See also: Anti-Ballistic Missile (ABM) Treaty; Intercontinental Ballistic Missiles; Minuteman ICBM; Missile Defense; Nike Zeus; Sentinel; Spartan; Sprint

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SAFEGUARDS

Safeguards are methods of controlling and handling nuclear materials, equipment, and technology of potential use in nuclear weapons programs. They are usually established in international agreements and treaties, implemented through domestic legislation, and subject to domestic and international regulation, oversight, and inspections.

A statute of the International Atomic Energy Agency (IAEA) authorizes it "to establish and administer safeguards designed to ensure that special fissionable and other materials, services, equipment, facilities, and information made available by the Agency or at its request or under its supervision or control are not used in such a way as to further any military purpose; and to apply safeguards, at the request of the parties, to any bilateral or multilateral arrangement, or at the request of a State, to any of that State's activities in the field of atomic energy." It thus typically falls to the IAEA to administer the safeguards related to the international nonproliferation regime. In this role, it conducts inspections and other verification activities (*see* International Atomic Energy Agency; Verification).

Safeguards ensure that there has been no diversion of declared nuclear material or illicit production of undeclared material at declared facilities. There are three main ways of accomplishing this objective. First, all nuclear material must be accounted for. Personnel thus establish the quantities of nuclear material present within defined areas and then record changes in these quantities over time. Second, containment and surveillance measures must be put into place. The IAEA takes advantage of physical barriers to restrict, control, or monitor the movement of or access to nuclear material. Finally, the credibility of the other two verification measures must be established. IAEA procedures dictate the use of on-site inspections. These activities are undertaken pursuant to negotiated agreements between the IAEA and nations with nuclear industries. Agreements in place prior to the Nuclear Nonproliferation Treaty (NPT) or with non-NPT members are called INFCIRC/66 (Information Circular Number 66) agreements. Agreements with NPT states parties are called INFCIRC/153 agreements. Both types of agreements have the primary objective of building confidence that states are complying with their nonproliferation commitments. IAEA safeguards were not designed to detect undeclared clandestine activities at undeclared nuclear facilities (*see* Nuclear Nonproliferation Treaty [NPT]).

In 1997, in response to its failure to detect Iraq's nuclear weapons program prior to the 1991 Gulf War, the IAEA developed a new "Model Protocol Additional" (INFCIRC/540) to append to the INFCIRC/153 agreements. This new protocol allows the IAEA to provide greater assurances concerning prohibited nuclear weapons activities under the NPT and to alert the international community to the possible production or diversion of nuclear materials for military purposes. The protocol requires states parties to provide extensive information, including data on the manufacture and export of sensitive nuclear-related technologies, to IAEA personnel. It mandates inspector access to all aspects of states parties' nuclear fuel cycle and gives inspectors the right to collect environmental samples. One important element of the new protocol is the affirmation of the right of the director general of the IAEA to conduct "special inspections" (both within and outside declared facilities and locations). This clause was already contained in INFCIRC/153 agreements but had rarely been applied in practice.

There are several complementary regional and bilateral nuclear inspection arrangements that do not directly involve the IAEA. Those in the European Union are performed by the European Atomic Energy Community (EURATOM) inspectorate of the European Commission, for example, and those between Brazil and Argentina are carried out by the Agency for Accounting and Control of Nuclear Material. There are also various bilateral agreements concerning safeguards and cooperation between other states (*see* European Atomic Energy Community).

During NPT negotiations, objections were raised regarding the perception that non–nuclear weapons states were put at a commercial disadvantage in competition with nuclear weapons states because IAEA safeguards were not required for the latter's nuclear activities, including the nuclear power industry. To achieve agreement on the NPT, the United States and all of the other nuclear weapons states put their civilian nuclear power industry under safeguards through the negotiation of a "voluntary offer" safeguards agreement with the IAEA (known as INFCIRC/288). Facilities used for nuclear weapons production were excluded from these inspections. Currently, the IAEA inspects four U.S. facilities. In addition, in 1993 the United States announced that it would place nuclear material deemed in excess of its defense needs under IAEA safeguards. In 1998, the United States also signed an Additional Protocol Agreement with the IAEA, which was ratified by the U.S. Senate in March 2004, and it has submitted a list of more than 200 facilities for possible safeguards arrangements under this protocol.

Under the Nuclear Nonproliferation Treaty, states parties pledge to negotiate and conclude agreements with the IAEA to accept and implement its safeguards system. The objective is to prevent "diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices." Each state party agrees not to provide any nuclear materials, equipment, or technology to any other state unless these materials are subject to safeguards. States are allowed to share nuclear information, materials, and technology for peaceful purposes.

Exporting countries formed two nuclear export control groups, the Nuclear Suppliers Group and the Zangger Committee, to maintain lists of these controlled items. The Nuclear Suppliers Group, currently made up of representatives from thirty-four nuclear supplier countries, established two sets of guidelines to govern the export of items for nuclear use, including dual-use items. The Zangger Committee, or Nuclear Exporters Committee, is an informal group of representatives from nuclear supplier states who meet regularly to define what constitutes, under Article III of the NPT, "equipment or material especially designed or prepared for the processing, use or production of special fissile material" and to set forth the conditions and procedures governing the exports of such items. These items are put on a "trigger list," that is, they are items that "trigger" IAEA safeguards and may be exported only if subject to safeguards.

—Guy Roberts

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SAFETY RODS

See Reactor Operations

SANDIA NATIONAL LABORATORIES

The creation of Sandia National Laboratories dates to the World War II Manhattan Project. Originally part of the Los Alamos Scientific Laboratory, Sandia began as Z Division in July 1945 and was created to perform ordnance engineering for the first atomic bomb and to assemble the weapon based on the designs produced by Los Alamos. Los Alamos in 1945 was crowded and suffered periodic water and other utility shortages, and the Manhattan Engineering District wanted a new home for field testing and weapon-assembly operations. Transportation shortfalls in the area also necessitated the relocation of production activities. All material for Los Alamos had to be trucked from the airfield in Albuquerque or from the rail depot in Lamy, both two hours away. A site near Albuquerque, New Mexico, was transferred to the army to be used as an assembly site for nuclear weapons components. Personnel from the Los Alamos Ordnance Division were transferred here, and it was operated as a branch of Los Alamos by the University of California. It was renamed Sandia Laboratory in 1948.

With the establishment of the Atomic Energy Commission after World War II, President Harry S. Truman asked the Bell System to manage activities at the site. On November 1, 1949, a new entity called Sandia Corporation (a wholly owned subsidiary of Western Electric) assumed direction of Sandia Laboratory (*see* Los Alamos National Laboratory; Manhattan Project).

Sandia is still primarily an ordnance engineering laboratory. It designs the nonnuclear parts of nuclear weapons. These include the electronics, arming, fusing, and firing systems, neutron generators, command and control devices, security and safety features, and new delivery concepts. Tritium reservoirs, weapons structure cases, aerodynamic shapes, and parachutes are also produced by Sandia. Until late 1947, the main assembly job at Sandia was to collect, inspect, and assemble the various weapon parts that remained in the U.S. inventory at the end of World War II into bombs. At the time, assembling components into a bomb took about sixty days, which was far too slow for U.S. military planners, who were hoping to have 400 bombs in the arsenal by 1951.

The main facility at Sandia is located on what is now Kirtland Air Force Base in Albuquerque. In 1956, Sandia established a lab at Livermore, California, to support the programs at Lawrence Livermore National Laboratory. Sandia also operates the Tonopah Test Range northwest of the Nevada Test Site. Sandia engineers developed concepts that allowed atomic bombs to be assembled and stored with little maintenance. It developed parachute systems for the safe deployment of nuclear gravity bombs. It also devised and produced the permissive action link, a device that permits only authorized users with the proper code to operate a nuclear weapon, for the U.S. inventory (*see* Permissive Action).

In conjunction with the two design laboratories (Lawrence Livermore and Los Alamos), Sandia is responsible for the research and development associated with weapon engineering for all phases of the nuclear-warhead life cycle. Sandia's major functions are in weapons research and development. It also improves existing weapons designs and engineers new weapons based on objectives such as reaching deeply buried targets.

Sandia collaborated with the Pantex Plant in Amarillo, Texas, to develop test assemblies used in Nevada until that work ceased following the imposition of a moratorium on nuclear testing in the United States in 1992 (*see* Moratorium; Pantex Facility, Texas). Sandia's real expertise lies in testing the effects of nuclear weapons on U.S. warheads. Sandia is also responsible for security, weapons safety, inventory control, and inventory maintenance of U.S. nuclear weapons. It trains military personnel who assemble and maintain nuclear weapons. The shipment, transportation, and containers for nuclear weapons are designed and tested by Sandia, and the storage bunkers and surveillance systems that monitor U.S. nuclear weapons storage sites are all designed by Sandia. The actual installation of these systems is conducted by the military service that owns the weapons and bunker, but Sandia inspects and certifies these installations.

Sandia has assumed a central role in designing the technology required to monitor and verify compliance with international accords. This know-how is also useful in monitoring foreign nuclear developments (*see* Verification). During the Cold War, when underground nuclear testing was still in progress, Sandia designed seismic arrays to monitor foreign nuclear tests and the nuclear Threshold Test Ban Treaty. In 1963, Sandia designed optical sensors that were installed on VELA satellites to monitor the globe for foreign nuclear explosions. Sandia worked on many of the Strategic Defense Initiative projects of the late 1980s. It has also produced numerous civilian technology spin-offs, such as laminar flow clean rooms, has spearheaded improvements in computer coding and processing, and has helped to design synthetic aperture radar, which can be used to look through clouds and weather.

—Gilles Van Nederveen and Jeffrey A. Larsen

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SAVANNAH RIVER SITE, SOUTH CAROLINA

Called the Savannah River Plant when it first opened in 1950 as a military facility devoted to the production of nuclear weapons, the Savannah River Site (SRS) was one of the largest nuclear weapons facilities in the Department of Energy's infrastructure and is capable of handling highly irradiated and extremely dangerous materials. The facility, which sits on 310 square miles (250,000 acres) on the east side of the South Carolina–Georgia border, is also one of the most polluted locations in the world. The site includes several distinct areas dedicated to different missions: the production reactors, the Savannah River Laboratory, a heavy-water plant, fuel and target fabrication facilities, and chemical separation (reprocessing) facilities.

Built by DuPont for the U.S. government, Savannah River's purpose was to provide the tritium necessary to boost the yield of thermonuclear weapons. Its reactors and reprocessing facilities would also provide plutonium, supplementing the production of the Hanford, Washington, facility. The plant provided all the heavy water (deuterium) produced in the United States until 1982, when that facility was closed. During the Cold War, five heavy-water reactors were built at Savannah River. Over their lifetime, these reactors produced 36 metric tons of weapons-grade plutonium (40 percent of the total U.S. production) and 225 kilograms of tritium.

Savannah River also produced some 34 million gallons of highly radioactive waste, which it stored at the site in tanks. Other poisonous substances were stored in a vast array of pits and basins around the complex. Leaks into local aquifers from both tanks and pits have occurred over the years, creating contamination problems. By 1988, all of the site's reactors had been shut down, mostly for safety reasons. Over $2 billion was spent in a short-lived attempt to restart one of the reactors in the early 1990s. The project was canceled when a leak of radioactive liquid developed in the cooling system. The fuels stored at the SRS, given their level of radioactivity and immensely long half-lives (rate of decay), will require close maintenance for hundreds, if not thousands, of years.

—*Rod Thornton and Jeffrey A. Larsen*

See also: Deuterium; Half-Life; Hanford, Washington; Heavy Water; Plutonium; Reprocessing; Tritium

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SCRAM

See Reactor Operations

SEA-LAUNCHED CRUISE MISSILES

Cruise missiles fired from surface ships and submarines are referred to as sea-launched cruise missiles (SLCMs). Cruise missiles are guided missiles with wings that fly primarily in a "cruise" mode, a state of flight that occurs when the engine's thrust is more or less equal to the air's resistance, aerodynamic lift is more or less equal to the weight of the aircraft, and the aircraft maintains an almost constant speed and altitude. Similar to other guided missiles, a cruise missile consists of four major components: an engine, a guidance system, a warhead, and a missile body. The cruise missile generally has an air-breathing jet engine and, from the moment it is launched until the moment it strikes its target, flies mainly in a "cruise" mode under the control of the engine's thrust and the guidance system (in contrast to the ballistic trajectory flown by most other missiles). Cruise missiles obtain their name from this flight profile.

Depending on the combat mission, a cruise missile can be classified as being either a strategic cruise missile or a tactical cruise missile. Missiles that are comparatively long range (generally considered to be a range greater than 500 kilometers) and are used to attack strategic targets are referred to as strategic cruise missiles. These cruise missiles have traditionally been equipped with a nuclear warhead and represent an important force in maintaining nuclear deterrence and providing an offensive nuclear-strike capability. As improvements have been made in their accuracy, it has become possible to use cruise missiles that carry a conventional warhead, and potentially a variety of more exotic nonnuclear warheads, to attack strategic targets. These innovations have reduced the significance of the distinction between strategic and tactical guided missiles, so that, as a rule, cruise missiles of this type are today referred to as conventional land-attack cruise missiles. Cruise missiles that have a shorter range and are used either to attack high-value ground targets or to attack ships are referred to as tactical cruise missiles.

Approximately nineteen countries currently produce cruise missiles, and several more have the capability to produce them. A least fifty-four other countries have cruise missiles of some type (air-launched, ground-launched, ship-launched, or submarine-launched) in their arsenals. Only a handful of countries currently possess submarine-launched cruise missiles, including the United States, France, the United Kingdom, and Russia. Modern cruise missiles are increasingly attractive because they can carry a warhead about the size of a ballistic missile over a similar range but can deliver it with far greater accuracy and at a fraction of a ballistic missile's cost. Moreover, the means to develop advanced cruise missiles can increasingly be obtained on the open market.

Under the first Strategic Arms Reduction Treaty (START I) signed in 1991, the United States and the former Soviet Union agreed to provide annual declarations regarding their deployment of strategic (nuclear) SLCMs. In a series of Presidential Nuclear Initiatives in 1991 and 1992, the United States and the Soviet Union also agreed to withdraw all tactical nuclear weapons from surface ships and submarines. Nearly all of the stocks of ground-launched cruise missiles that were developed by the United States and the Soviet Union have been eliminated in accordance with the provisions of the 1987 Intermediate-Range Nuclear Forces (INF) Treaty (*see* Intermediate-Range Nuclear Forces Treaty; Presidential Nuclear Initiatives; Strategic Arms Reduction Treaty).

The primary SLCM for the United States is the BGM-109 Tomahawk. The Tomahawk is an all-weather surface or underwater (submarine)-launched land-attack cruise missile. After launch, a solid propellant propels the missile until a small turbofan engine takes over for the cruise portion of flight. Tomahawk is a highly survivable weapon. Its small cross-section and low-altitude flight make it extremely difficult to detect on radar. The Tomahawk land-attack cruise missile has been used to attack a variety of fixed targets, including air defense and communications sites, often in high-threat environments.

The primary SLCM deployed by Russia will likely be the NE-08 and the SS-N-21, both of which have characteristics similar to the Tomahawk. The NE-08 will be deployed on surface ships and the SS-N-21 on submarines. An advanced model of the SS-N-21 (P version) is under development.

The focal point of advanced research on all types of cruise missiles is to improve the missiles' ability to penetrate enemy defenses. Countries are developing cruise missiles that have enhanced stealth characteristics or that fly low at subsonic speeds to evade detection and tracking by enemy radar. For example, the radar cross-section of the U.S. advanced cruise missile is less than 0.01 square meter, making it very hard for enemy radar to detect and track its flight. Another approach to increasing the ability to penetrate defenses is to emphasize research and development of supersonic and hypersonic cruise missiles, which would be very difficult to intercept. The United States, for example, is currently exploring the possibility of developing hypersonic cruise missiles that may travel at speeds as high as Mach 8. Russia, too, is engaged in research and development work on supersonic cruise missiles.

—*Guy Roberts*

See also: Cruise Missiles

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SECOND STRIKE

The term "second strike" refers to the ability of a state to retaliate with its nuclear weapons after absorbing another country's initial attack. To have a second-strike capability, a state must have weapons that are hidden (that the enemy cannot hit because he does not know about them), that are impervious to attack (stored in such a way that a nuclear strike would not damage or destroy them), or that cannot be targeted (such as on deployed submarines). Even in the event of a surprise nuclear attack, a country that possessed a secure second-strike capability would retain some nuclear weapons that could be launched against the enemy.

During the Cold War, the United States and the Soviet Union built survivable nuclear forces to create a second-strike capability that took the form of a "Triad" of land-based intercontinental ballistic missiles (ICBMs), bombers, and deployed submarines.

Because submarines are difficult to locate, it would be hard for a state to determine that it had located and destroyed all of the adversary's submarines, thereby eliminating the opponent's ability to retaliate. Today any state with nuclear weapons deployed on submarines can be assumed to have a secure second-strike capability.

A secure second-strike capability is key to nuclear deterrence and crisis stability. The guarantee that a state will have nuclear weapons in reserve that can be used to retaliate against aggression can deter attack because the opponent can expect retaliation from surviving weapons. Crisis stability is enhanced because no state has any incentive to launch its nuclear weapons first in a crisis if its leaders expect that the attack will only invite a nuclear second strike (*see* Crisis Stability; Deterrence).

A second-strike capability also reduces the incentives for officials to adopt a launch-on-warning policy by firing a retaliatory strike upon detection of an incoming attack. Because decision makers with a secure second-strike capability know that they can absorb a nuclear strike—especially a small nuclear strike—they can wait to assess the unfolding situation before choosing an appropriate response. A secure second-strike capability eliminates the need to make snap judgments in crisis and wartime, judgments that could lead to nuclear accidents or inadvertent escalation.

—*Andrea Gabbitas*

See also: Escalation; First Strike; Flexible Response; Launch on Warning/Launch under Attack; Massive Retaliation; Selective Options; Survivability

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SELECTIVE OPTIONS

As a situation of mutual assured destruction between the United States and the Soviet Union became a reality in the late 1960s, U.S. nuclear war plans began to contain ideas about limiting escalation and avoiding countervalue attacks when possible. By making nuclear attacks more selective, planners believed that they could increase the credibility of nuclear deterrence despite the prospect that retaliation in kind was inevitable. National Security Decision Memorandum 242 (NSDM-242), issued by the Gerald Ford administration in 1974, reflected this new approach to nuclear targeting. It provided the president with a range of nuclear options, offered a prospect of controlling escalation, and devised a series of "nuclear withholds" (targeting options that excluded certain categories of targets). (*See* Counterforce Targeting; Countervalue Targeting; Escalation.)

The Jimmy Carter administration continued the effort to create "credible" nuclear targeting options. Presidential Directive 59 (PD-59) called for the development of selective counterforce options in the nuclear war plan, especially options to target centers of Soviet political and military control. The Carter administration also took steps to improve the survivability of U.S. nuclear command and control to be able to execute selective counterforce options even after suffering a Soviet nuclear attack. Ronald Reagan's administration focused on improving the ability of the United States to conduct prompt counterforce attacks by developing new delivery systems (including the MX–rail garrison intercontinental ballistic missile and the Trident II D5 submarine-launched ballistic missile) that provided a secure second-strike counterforce capability. These efforts to create secure nuclear second-strike capabilities and options were largely suspended with the end of the Cold War.

The rise of the U.S. precision global strike complex has added a new dimension to the prospect of devising selective options. The 2002 Nuclear Posture Review calls for the integration of nuclear and conventional strike options to hold critical targets at risk, especially small arsenals of nuclear, chemical, and biological weapons. Planners also have been instructed to abandon the deliberate planning method used during the Cold War to develop selective nuclear attack options. Instead, planners use adaptive, capabilities-based planning to devise options tailored to meet specific contingencies.

—*James J. Wirtz*

See also: Deterrence; Second Strike

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SENTINEL ANTI-BALLISTIC MISSILE SYSTEM

The 1960s-era Sentinel antiballistic missile (ABM) system was intended to provide protection of the United States from a Soviet missile attack. The program was to consist of two different types of nuclear-tipped missiles, one designed to intercept incoming Soviet warheads in the exoatmosphere and a second, shorter-range missile to strike any remaining warheads once they reentered the Earth's atmosphere. From its inception, however, the program was contentious. For individuals such as U.S. Secretary of Defense Robert McNamara, the program represented a direct challenge to the concept of assured destruction. If either side developed a successful defensive system, then deterrence could no longer be based on the threat of holding the opponent's homeland at risk. For others, Sentinel was desirable because it held out the prospect of restoring America's ability to strike the Soviet Union with relative impunity. Within the scientific community there was considerable opposition even to limited deployment, and the pages of *Scientific American* were used as the main forum for the critique of the program. With the Vietnam War in the background, public opinion was against deploying interceptor missiles armed with nuclear warheads based near urban areas.

President Richard M. Nixon's administration sought to deflect criticism of the U.S. ABM program by announcing in March 1969 the reorientation of the program away from the defense of cities and toward the defense of U.S. intercontinental ballistic missile silos against a Soviet attack. Now called Safeguard, the system was intended to ensure that the United States retained an assured destruction capability against the Soviet Union. This change in the mission of the planned U.S. ABM system also was subjected to much criticism. The program remained a key negotiating chip for the United States during the Strategic Arms Limitation Talks (SALT I and II).

—*Andrew M. Dorman*

See also: Deterrence; Missile Defense

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SHORT-RANGE ATTACK MISSILES (SRAMS)

After the cancellation of the Skybolt air-launched ballistic missile in December 1962, the U.S. Air Force had to devise another way to modernize the strike capabilities of its strategic bomber force. The Strategic Air Command (SAC) proposed the development of a short-range, air-to-ground attack missile (SRAM) in 1963 and accepted its first SRAM in 1972. SRAM was a small missile that could fly 100 miles with a W69 nuclear warhead. Designed to attack targets such as air defense sites from either high or low altitude in any direction from its carrier aircraft, the SRAM allowed a SAC bomber to strike multiple targets. The 2,240-pound SRAM was powered by a two-stage solid-fuel rocket motor. The first motor stage propelled the missile to Mach 3, and the second stage was ignited near the target for a powered terminal approach. Maximum range varied from 55 kilometers (35 miles) for low-altitude launches to 160 km (100 miles) for high-altitude firings. The SRAM was guided by an inertial navigation system, assisted by a terrain clearance sensor, and could achieve an accuracy (or circular error probable) of about 430 meters (1,400 feet). (*See* Accuracy.)

The weapon was originally proposed for the B-52G and H fleets, but the FB-111 and B-1 also carried the weapon. Each B-52 bomber could carry eight SRAM missiles on a rotary launch "revolver" cylinder carried in the aft bomb bay. Pylons under each B-52 wing, which were built to carry Hound Dog missiles, were modified to carry six SRAMs each, for a total load of twenty SRAMs per B-52. FB-111s could carry a maximum of six SRAMs, but a normal load was four, two in the weapons bay and two more on the inboard wing pivot points. The B-1 could be fitted with the B-52 rotary launcher in each of its three weapon bays. For both the B-52 and the B-1, one rotary launcher was usually installed in the aft weapons bay, while the other weapons bay held four thermonuclear gravity bombs. A total of 1,500 SRAMs were produced. The weapons were removed from the bombers on June 7, 1990, as part of President George H. W. Bush's nuclear force reductions at the end of the Cold War.

—*Gilles Van Nederveen*

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SHROUDING

Shrouding is a managed access technique often used during arms control inspection procedures that involves either completely or partially covering an object from view. This technique is used to prevent visitors or international inspectors from being able to view proprietary or national security information. Shrouding conceals large objects, panels on objects, or the size and design of an object. If an entire machine or object needs to be protected, then a tarp or trash bag can be used to cover the object. If the size and shape need to be protected, a large box can be used to cover the object, or items can be placed under a tarp to conceal or alter the shape of the machine being shrouded. To shroud only part of an object, black tape and cardboard can be used to cover panels on a machine or words on a pipe that might give away a proprietary process.

Whenever shrouding or any managed access technique is used under an arms control agreement or treaty, the inspected party must make every attempt possible to demonstrate treaty compliance to the party carrying out the inspection. This could include partially removing a shroud or providing documentation about the compliance concern instead of granting full access to an area.

—Robert Wyman

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SILO BASING

Missile "silos" are heavily reinforced-steel and concrete underground structures that can be hardened to withstand thousands of pounds of blast overpressure generated by a nuclear detonation. Intercontinental ballistic missiles (ICBMs) are usually based in silos. Compared to road-mobile, air-launched, and sea-based missile launch platforms, silos enjoy higher alert rates and better communications and security, although in the past thirty years improvements in accuracy have made them increasingly vulnerable to both nuclear and conventional attack.

An intercontinental ballistic missile in its hardened underground silo. (Marvin Koner/Corbis)

Initially, silo-based missiles represented the most secure nuclear deterrent available to the United States and the Soviet Union. Since the silos were constructed deep within the territory of their respective states, and ICBMs often had a circular error probable (CEP) measured in miles (*see* Accuracy), silos offered a relatively inexpensive, effective, and survivable way to deploy ICBMs. As missile accuracies improved, however, missile silos (which could be located using satellite reconnaissance) and the weapons they sheltered became vulnerable to destruction.

However, the silo also has weaknesses in comparison with other warhead-delivery platforms. Most important, silos cannot move. Since they are in a fixed position, attacking forces know exactly where to target silos. To help improve survivability, most U.S. missile silos were hardened to withstand 2,500–4,000 pounds per square inch (psi) of pressure. Some were hardened to 7,000 psi. There was even research to create a "super-hard" silo capable of withstanding 50,000 psi. Some officials also suggested novel ways to incorporate silos in innovative basing schemes. The "racetrack" option involved moving ICBMs within a chain of connected silos so that Soviet intelligence would never know exactly where the missile was located at any given moment. The shelters would be dispersed and hardened, requiring the Soviets to expend dozens of warheads to destroy a single ICBM. Construction of this type of "warhead sink" was expensive and used vast tracks of land and raw materials, especially water. Another option, "dense pack," involved the construction of silos grouped closely together so that "fratricide" (the tendency of nearby nuclear explosions to damage other incoming warheads) would wreak havoc among a wave of attacking warheads, thus allowing a substantial portion of the defending force to survive the attack. Critics worried, however, that by continually subjecting the dense pack to a creeping missile barrage, Soviet forces could achieve a mission kill against the ICBM force by preventing missile launch.

—*Abe Denmark*

See also: Dense Pack

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SINGLE INTEGRATED OPERATIONAL PLAN (SIOP)

As new weapon systems and new ways of fighting have emerged, the requirement to command and control such capabilities has remained, but the means by which this control is exercised has changed. The advent of nuclear weapons posed significant new challenges for command and control in wartime because failure of positive or negative control could have potentially devastating results. Since the Dwight D. Eisenhower administration, successive Single Integrated Operations Plans (SIOPs) have been developed to manage how U.S. nuclear forces would be used in war. Shrouded in secrecy, and with many attendant myths, successive plans have been developed over the years to encompass a variety of targeting options based on broad guidance received from successive presidents, secretaries of defense, and the Joint Chiefs of Staff. The SIOP has been the employment plan for several declaratory nuclear doctrines, including assured destruction in the 1960s and sufficiency and controlled response in the 1970s.

History and Background

The SIOP was developed initially by Strategic Air Command (SAC, now U.S. Strategic Command, or STRATCOM) in its Joint Strategic Targeting and Planning Section (JSTPS) as a way to integrate a growing multiservice and multiplatform U.S. nuclear arsenal into a coherent war plan and to develop operational war plans that matched civilian guidance on nuclear deterrent policy. The SIOP was literally a *single* plan produced through a deliberate planning process that often took years to complete. Its goal was to use all available nuclear weapons under day-alert and fully generated scenarios to maximize damage against the Soviet Union and its allies. A secondary goal was to deconflict attack routes and time over target to minimize fratricide. The John F. Kennedy administration did not like the single option provided by the first SIOP, known as SIOP-62, and pushed for additional policy options. Administration officials argued that the single option failed to give the president flexibility in meeting unexpected contingencies. Successive SIOPs have since been developed that offered an increasing array of attack options to the president as a means of attempting to control nuclear escalation. A more flexible SIOP was supposed to increase the credibility of deterrent threats because it provided several limited options that might be used under dire circumstances to demonstrate resolve or to terminate a conflict quickly on U.S. terms (*see* Credibility; Deterrence).

With the end of the Cold War, the transformation of SAC to STRATCOM, and the need for even more flexibility when it came to planning for unexpected threats and conflicts, the deliberate and time-consuming SIOP planning process is being phased out in favor of an adaptive "capabilities-based" planning process. The 2001 Nuclear Posture Review produced by the George W. Bush administration marked a watershed in the history of U.S. nuclear policy. Planners may now be able to plan military operations on relatively short notice using a menu of nuclear and nonnuclear strike options. Instead of focusing on guaranteeing that a massive nuclear attack can be launched against the Soviet

Union under all circumstances, planners now focus on providing options and capabilities to match all conceivable future threats. New versions of the "SIOP" will create additional requirements for improved command and control (*see* Nuclear Posture Review).

Technical Details

The SIOP integrates all the nuclear weapons maintained by the various services and all the plans of the various commands to ensure civilian control over nuclear weapons and to ensure that nuclear weapons are used in a coherent manner to produce some tangible military effect. Planning for such an eventuality has rested with a joint targeting team, traditionally under the command of a navy flag officer stationed at Offutt Air Force Base, Omaha, Nebraska.

Presidents do not become fully familiar with the SIOP and their responsibilities until they receive their SIOP briefing, which is developed by military staffs at STRATCOM. The SIOP describes to the president the range of targeting options he would have available should he decide to employ them. It is framed in terms of launch procedures and the target sets against which the weapons will be launched. The executive version of the SIOP, including the code books and unlock authority for weapons, often is visible to the public. Known as the "football," it consists of a briefcase carried by an officer who accompanies the president wherever he goes. In the event that the president becomes incapacitated (such as after the attempted assassination of Ronald Reagan in 1982), access to the football can pass to others, for example, the vice president, along with authority to command the U.S. nuclear arsenal (*see* The Football).

Implementing and maintaining the SIOP requires the continual updating of the command and control system, a significant reconnaissance and interpretation capability, and the maintenance of alert based nuclear forces. These are regularly tested. The results of the various war games have been kept secret, although elements from them have leaked. The SIOP requires the preservation of a leadership to authorize nuclear release, and this means that the president and his successors need to remain invulnerable. As a result, forces are always on alert to move the president out of harm's way and get him aboard the special Boeing 747 command aircraft, which is currently designated the National Emergency Airborne Command Post (NEACP). (*See* National Emergency Airborne Command Post [NEACP].)

Traditionally, the SIOP was based on an effort to match available weapons to various target sets. Targets have included Russian nuclear bases and other military targets, leadership headquarters, and urban industrial targets. Using sophisticated modeling techniques, planners calculate how hard each potential target would be to destroy, what type of nuclear weapon should be used, how many weapons would need to be allocated to destroy it, and how much damage such an attack would be likely to have in terms of both physical damage and human casualties.

—*Andrew M. Dorman and James J. Wirtz*

See also: Strategic Air Command and Strategic Command

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SKYBOLT

The Douglas AGM-48A Skybolt was an air-launched missile with a nuclear warhead that was to have been deployed on U.S. B-52 bombers in a plan that would have transformed the bombers into mobile ballistic missile launchers. It was a joint project with Great Britain, which intended to use Skybolt to modernize its independent nuclear force of Vulcan bombers. In return for codevelopment of the missile, the British agreed to grant the U.S. Navy access to the Holy Loch submarine base in Scotland.

Skybolt was a 39-foot, two-stage missile that weighed 11,000 pounds and had a range of 950 nautical miles. When dropped from a B-52 at 40,000 feet, the missile could reach its target in as little as 12 minutes. The government initially intended to build 1,000 Skybolt missiles to equip 22 bomber squadrons by mid-1967 for $2.5 billion ($600 million of this cost was tied up in equipping Skybolt with its 800-kiloton warhead). The missile's primary mission, defense suppression, would have been to destroy air defense batteries, thereby providing the bombers clear paths to Soviet targets.

Skybolt was canceled in December 1962 by the John F. Kennedy administration because of concerns about cost and effectiveness. This decision led to a major crisis in Anglo-American relations. To smooth over tensions with British allies, the Kennedy administration, following the Nassau Summit, promised to provide Great Britain with access to the Polaris submarine-launched ballistic missile. This offer, in turn, angered French officials, leading to their veto of British entry into the European Economic Community in January 1963.

—*Glen M. Segell*

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SOUTH AFRICAN NUCLEAR WEAPONS PROGRAM

South Africa was a secret nuclear weapons state in the 1980s and 1990s until unilaterally renouncing its program and destroying its six warheads in 1994. Readily available South African sources of yellowcake had helped to fuel the nuclear industry in the United States immediately after World War II. Reciprocally, South Africans were trained in the United States, which later provided South Africa with a nuclear research reactor. This arrangement operated under a safeguards agreement between the International Atomic Energy Agency (IAEA), the United States, and South Africa. In 1957, the United States signed a bilateral nuclear cooperation agreement with South Africa that committed Washington to supply enriched uranium to the regime in Johannesburg.

Although South Africa had signed the 1963 Limited Test Ban Treaty, it refused to sign the 1968 Nuclear Nonproliferation Treaty (NPT). In 1971, South Africa began investigations into building a nuclear device. This initiated deep suspicion over South Africa's long-term intentions, especially because the country faced growing international isolation over its policy of apartheid. Three years later, the South African government authorized a nuclear program and began secret work on a nuclear test site in the Kalahari Desert.

Notwithstanding efforts to use its strategic location to impress its importance to the West, pressure on South Africa both over apartheid and over its nuclear program increased by the mid-1970s. The Jimmy Carter administration was especially active in the quest to end apartheid. Although Washington opposed a complete ban on nuclear cooperation with South Africa, the 1978 U.S. Nuclear Non-Proliferation Act (NNPA) ended the possibility for the reexport of enriched uranium (even of South African origin) to South Africa to fuel a French-built nuclear power station. In response, South Africa set out to develop local alternatives by constructing a plant to produce highly enriched uranium (HEU) on an industrial scale (*see* Enrichment; Highly Enriched Uranium [HEU]).

In August 1977, the Soviets detected preparations for a "cold test" at the Kalahari facility. Setting aside ideological differences, the superpowers pressured South Africa not to go forward with its nuclear program. Two years later, however, the United States detected a low-yield, high-altitude nuclear explosion off South Africa's coast. What happened remains a mystery. The possibility of nuclear cooperation with Israel remains the most plausible explanation of the event. In 1977, South Africa was removed from its seat on the IAEA board of governors and replaced by Egypt; two years later it was denied participation in the IAEA General Conference. South Africa also might have sold enriched uranium to Iraq in the late 1980s.

The end of apartheid broke the impasse over South Africa's nuclear program. In early July 1991, South Africa acceded to the NPT, and it completed its IAEA safeguards agreement three months later. In March 1993, South Africa's last minority-elected president, F. W. de Klerk, announced the unilateral dismantling of its six nuclear weapons. Some believe that the decision was made to prevent technology from falling into the hands of a "black government" or to halt the possible transfer of weapons-grade uranium to Libya, Cuba, or the Palestine Liberation Organization. The country's majority-elected government also has followed a nonnuclear policy.

South Africa joined the Zangger Committee in 1994 and the Nuclear Suppliers Group in 1995. Its officials were instrumental in winning indefinite extension of the NPT in 1995 and played a leading role in the successful conclusion of the 2000 NPT Review Conference as a member of the "New Agenda Coalition."

—*Peter Vale*

See also: Nuclear Nonproliferation Treaty (NPT); Nuclear Suppliers Group; Zangger Committee

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SOUTH KOREAN NUCLEAR WEAPONS PROGRAM

Since the end of the Korean War in 1953, the Republic of Korea (ROK, or South Korea) has occasionally made limited attempts to pursue the development of weapons of mass destruction. However, it joined the nonproliferation regime in 1975 when it signed the Nuclear Nonproliferation Treaty (NPT) and has maintained its commitments under that treaty. The country, which came into existence in August 1948, has meanwhile had to contend with the threat of weapons of mass destruction in the Democratic People's Republic of Korea (DPRK, or North Korea). South Korea has maintained a close relationship with the United States and now finds itself precariously positioned between the brinkmanship of Pyongyang and Washington's identification of North Korea as a "rogue state."

Under the dictatorship of General Park Chung Hee, South Korea pursued a nuclear weapons program in the 1970s but backed down under U.S. pressure before producing any fissile material. In 1972, South Korea discussed the acquisition of a nuclear plant with Canada and France. A contract with France for the purchase of a reprocessing plant was signed early in 1975. The significance of these negotiations was apparent to U.S. officials, who placed pressure on the South Koreans to abandon any ambitions to build a nuclear weapon. South Korea yielded to U.S. pressure and canceled its order for nuclear reprocessing plants (*see* Reprocessing).

When South Korea signed the NPT in 1975, it accepted all International Atomic Energy Agency (IAEA) inspection and auditing procedures. In 1991, President Roh Tae Woo declared that South Korea would not "manufacture, possess, store, deploy, or use nuclear weapons" and added that Seoul would not possess nuclear fuel reprocessing and enrichment facilities. In 1992, North and South Korea signed the Joint Declaration on the Denuclearization of the Korean Peninsula and the Basic Agreement, under which the two sides promised reconciliation, nonaggression, exchanges and cooperation, and the denuclearization of the Korean peninsula. Both sides, however, have failed to implement the bilateral inspection regime called for by these agreements (*see* International Atomic Energy Agency; Joint Declaration on Denuclearization of the Korean Peninsula; Nuclear Nonproliferation Treaty [NPT]).

North Korea's nuclear ambitions have continued to supply evidence in support of a hard-line minority in the South Korean legislature that wants to match North Korea's nuclear programs. Although South Korea initially renounced its right to reprocess and enrich nuclear fuel, the revelations regarding North Korea's clandestine nuclear program in the early 1990s caused a change in policy. South Korea set up a reprocessing plant at a nuclear research facility outside of Seoul to close its nuclear fuel cycle and give it nuclear independence.

All South Korean nuclear facilities and materials are under full-scope international inspections by the IAEA, in compliance with its NPT safeguards obligation, and there is no suspicion of a covert nuclear program. In 2002, following further declarations from North Korea that it is pursuing a nuclear program, South Korean president Kim Dae Jung issued a statement with U.S. president George W. Bush and Japanese prime minister Junichiro Koizumi condemning North Korea's pursuit of nuclear weapons, declaring it a violation of the Agreed Framework, the NPT, North Korea's IAEA safeguards agreement, and the Joint Declaration on Denuclearization of the Korean Peninsula. Today, South Korea is a "virtual" nuclear power, a country that has the technical capability needed to build a nuclear arsenal but has made the political decision not to acquire nuclear weapons.

—J. Simon Rofe and Elizabeth Aylott

See also: North Korean Nuclear Weapons Program

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SOVIET UNION

See Bombers, Russian and Chinese Nuclear-Capable; Chelyabinsk-40; Chernobyl; Moscow Antiballistic Missile System; Nuclear Warhead Storage and

Transportation Security (Russia); Russian Nuclear Forces and Doctrine

SPACE-BASED INFRARED RADAR SYSTEM (SBIRS)

The Space-Based Infrared Radar System (SBIRS) is the planned follow-on surveillance system to the aging Defense Support Program (DSP) system. During the Cold War, the United States constructed a network of surveillance posts, radar sites, and satellite systems to provide early warning of a first strike attack by the Soviet Union. One of these systems was the DSP, a constellation of infrared satellites in geostationary orbit. First launched in November 1970, DSP's primary mission remains detection and warning of missile launches through recognition of their boost phase.

SBIRS is being developed to meet U.S. surveillance needs during the next two to three decades. Its four primary missions are missile warning, missile defense, technical intelligence, and battlespace characterization. SBIRS is a "system of systems" that will integrate space assets in several orbit configurations with a consolidated ground segment to provide effective integration of data and improved transmission of data to the battlefield.

The SBIRS architecture includes satellites located in Geostationary Earth Orbit (GEO), Highly Elliptical Orbits (HEO), and Low Earth Orbit (LEO) to provide global coverage in support of its four missions. The satellites in GEO and HEO, "SBIRS-High," provide improved missile warning and defense. Those in LEO, originally termed "SBIRS-Low," track ballistic missile targets through midcourse and terminal flight. In 2002, the SBIRS-Low program was restructured, incorporated into the Missile Defense Agency, and renamed the Space Tracking and Surveillance System (STSS). STSS will detect and track ballistic missiles; in addition, it will enhance the ability of ballistic missile defense system interceptors to differentiate the warhead of an incoming missile from other nearby objects, such as decoys.

—Patricia McFate

See also: Decoys; Early Warning; Missile Defense; Surveillance

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SPARTAN MISSILE

The Spartan air-defense missile was designed as the first line of defense in the U.S. Sentinel and Safeguard antiballistic missile programs of the 1960s and 1970s. The earlier Nike-X system had incorporated two missiles; one of them was exoatmospheric, that is, a long-range missile designed to intercept warheads outside of the Earth's atmosphere. Work on an extended-range Nike-Zeus B (or Nike-Zeus EX) was started in 1965. The name of this missile was changed to Spartan two years later, when the Nike-X system was renamed Sentinel (*see* Anti-Ballistic Missile System; Nike Zeus; Sentinel).

The first test of this missile occurred in March 1968. The Spartan carried a large, multimegaton warhead that was designed to kill an enemy reentry vehicle (RV) by X-ray radiation flux, rather than by blast. In this sense, its warhead was the first enhanced radiation weapon, or "neutron bomb." Spartan had a range of 460 miles. In August 1970, a Minuteman RV was successfully intercepted by a Spartan for the first time. In January 1971, Spartan intercepted a Polaris submarine-launched ballistic missile that had deployed decoys and penetration

Two Spartan missiles are launched seconds apart en route to a successful intercept of an ICBM reentry vehicle high over the Pacific as part of the Safeguard ABM system tests at the Kwajalein Range, January 1971. (Bettmann/Corbis) aids in an attempt to overwhelm the Spartan radar systems (*see* Neutron Bomb [Enhanced Radiation Weapon]; Penetration Aids).

The Sentinel system soon gave way to Safeguard, the antiballistic missile system the United States eventually deployed in 1975 at Grand Forks, North Dakota. Thirty Spartan interceptors were stored in underground silos along with seventy high-speed Sprint interceptors.

—*Gilles Van Nederveen*

See also: Safeguard Anti-Ballistic Missile System; Strategic Defenses

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SPENT FUEL

See Reactor Operations

SPRINT MISSILE

The Sprint air-defense missile was designed to serve as the point defense missile in the U.S. Sentinel and Safeguard antiballistic missile (ABM) systems of the 1960s and 1970s. It was endoatmospheric, that is, designed to intercept missiles within the Earth's atmosphere. In November 1965, the first Sprint was tested after research showed that a very high speed interceptor was possible.

The cone-shaped Sprint was powered by a two-stage solid-propellant rocket motor. The motor ignited after the missile had been ejected from its underground silo by gas pressure and was capable of accelerating at more than 100 G's. The missile reached a speed greater than Mach 10, and the extreme thermodynamic heating demanded sophisticated ablative shielding. The nose of the Sprint actually glowed a second after launch. Special command links, hardened and protected against electromagnetic pulse, guided the missile. The Sprint was equipped with a low-yield enhanced radiation warhead that was intended to destroy the incoming reentry vehicle with a very high neutron flux. The flight time for an intercept was expected to be less than 15 seconds.

Testing continued until 1973, validating the design, and seventy Sprints were deployed in North Dakota as part of the Safeguard ABM system. That system was inactivated in 1975.

—*Gilles Van Nederveen*

See also: Missile Defense; Neutron Bomb (Enhanced Radiation Weapon); Safeguard Antiballistic Missile System; Sentinel; Strategic Defenses

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SPUTNIK

Sputnik, launched by the Soviet Union on October 4, 1957, was the world's first artificial satellite. Two more Sputniks were launched on November 3, 1957, and May 15, 1958. In opening the space age, Sputnik caused an international sensation. In response, the United States established the National Aeronautics and Space Administration (NASA). Sputnik thus inspired the space race that culminated in the U.S. moon landings twelve years later.

Sergey P. Korolev, who would become Soviet chief missile designer, began preliminary work on a satellite program in the early 1950s. In May 1954, he requested permission to develop and launch a satellite on an RL-7 booster, but the government did not give full approval to the satellite project, called Object D, until January 1956. The approval was influenced by the U.S. announcement in July 1955 of plans to launch a satellite during the International Geophysical Year (IGY) scheduled to begin in 1957. News in September 1956 that the U.S. Army had launched a Jupiter C on a ballistic flight over a distance of 5,300 kilometers prompted Korolev to modify his efforts to avoid being beaten into space. In November 1956, he introduced a lighter and more modest satellite proposal. This version was approved in February 1957 and became *Sputnik I.*

It would be hard to overstate the dramatic effect of the Sputniks on world, and especially U.S., public opinion. The Soviet space triumphs accelerated the growing feelings of insecurity experienced by many Americans during the early years of the nuclear age. The U.S. response to the challenge was broad and deep, ranging from bolstering education to increased military spending and government reorganization.

—*Peter Hays*

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STANDING CONSULTATIVE COMMISSION

The Standing Consultative Commission (SCC) was a forum established to help implement the objectives and provisions of the May 1972 Anti-Ballistic Missile (ABM) Treaty and to deal with ambiguities and compliance questions related to the treaty. Article XIII of the ABM Treaty provided for the establishment of the SCC, and a December 1972 Memorandum of Understanding (MOU) between the United States and the Soviet Union established the Commission. The MOU also gave the SCC jurisdiction over the Accidents Measures Agreement of 1971 and the 1972 Interim Agreement on Strategic Offensive Arms. The SCC was thus charged with dealing with the three associated agreements that emerged during the first Strategic Arms Limitation Talks and Treaty (SALT I). The SCC also helped to implement the signed but never ratified 1979 SALT II Treaty. From the late 1980s, the SCC exclusively concerned itself with ABM Treaty–related issues. The SCC served as a model for later arms control treaty implementation commissions, such as the Special Verification Commission of the 1987 Intermediate-Range Nuclear Forces (INF) Treaty and the Joint Compliance and Inspection Commission of the 1991 Strategic Arms Reduction Treaty (START I).

The SCC MOU established basic organizational matters but left much discretion to U.S. and Soviet officials as to how the SCC should actually operate. Each side was to be represented by a commissioner and a deputy commissioner, assisted by such staff as it deemed necessary. Commission sessions were to be held not less than two times per year and could be convened as soon as possible, following reasonable notice, at the request of either commissioner. The sessions were to be held in Geneva, Switzerland, unless another location was selected by mutual consent. The SCC was charged with making its own regulations and could revise, repeal, or replace the regulations as it deemed necessary. The United States and the Soviet Union agreed upon regulations in May 1973 at the opening of the first SCC session.

After the dissolution of the Soviet Union in December 1991, an issue arose about which of the Soviet successor states were or should be parties to the ABM Treaty, and by extension, the SCC. In September 1997, a Memorandum of Understanding on ABM Treaty succession was signed by the United States, Russia, Belarus, Kazakhstan, and Ukraine. An associated document provided revised regulations to govern the multilateral operation of the SCC. These ABM Treaty succession documents, however, were overtaken by events and never entered into force.

Although Russia, Belarus, Kazakhstan, and Ukraine attended SCC sessions from 1992 until 2001, in the absence of entry into force of the ABM Treaty Succession MOU, the status of the Soviet successor states with respect to the ABM Treaty and the SCC was never resolved. The United States gave a six-month notice of its intention to withdraw from the ABM Treaty on December 13, 2001. This withdrawal notice was given pursuant to the withdrawal requirements of Article XV of the ABM Treaty. U.S. withdrawal took effect on June 13, 2002. The SCC ceased to function after its sixty-third session in December 2001.

—*Steven Rosenkrantz*

See also: Anti-Ballistic Missile Treaty; Intermediate-Range Nuclear Forces Treaty; Strategic Arms Limitation Talks; Strategic Arms Reduction Treaty

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STEALTH BOMBER (B-2 SPIRIT)

The U.S. Air Force B-2 stealth bomber is America's premier long-range nuclear and conventional strategic bomber. The stealth bomber project was first announced by the Carter administration in the

A B-2 Spirit bomber from Whiteman Air Force Base in Missouri drops a B-61/11 "bunker buster" bomb in a March 1998 test. (Reuters/Corbis)

heat of the 1980 presidential campaign, in response to Republican criticism of the decision to cancel the B-1A bomber. Since its unveiling on November 22, 1988, the bomber has been highly controversial for its high development and production costs—$45 billion—and high ongoing maintenance costs.

When the Rockwell B-1A was canceled in 1977, design work on a new bomber with stealth technology was already under way. The program, codenamed Advanced Technology Bomber (ATB), was officially launched in 1978. In 1981, Northrop's design was chosen over a Lockheed/Rockwell concept. Boeing would play a large role as a Northrop subcontractor. The U.S. Air Force originally planned to acquire 133 B-2s, which were designed to penetrate Soviet airspace and attack mobile intercontinental ballistic missile (ICBM) launchers such as the SS-24 and the SS-25.

The B-2 was to take over the penetration mission from the 100 B-1Bs that had been procured by the air force in the mid- to late 1990s. The B-1s, in turn, were to take over the stand-off attack mission from the B-52s. The B-2 needed to survive the penetration of Soviet airspace and be undetectable as it attacked strategic targets inside the Soviet Union. The B-52 and B-1 fleets relied on low-altitude mission profiles with extensive countermeasures, which have the drawback of giving away their position and making them vulnerable to detection. The B-2 thus had to incorporate new low-observable technology that already had been developed for a fighter-sized aircraft, the F-117. Since the stealth low-observable technology had worked, a bomber was quickly proposed.

Although work on the ATB was clouded in secrecy, it was soon rumored among aviation enthusiasts that Northrop's design was a variation of its flying-wing work from the 1940s. Northrop had built the XB-35 and XB-49 flying wings, but neither was ultimately accepted into service. Both were advanced for their time. A flying-wing bomber has no fuselage or tail, so there is less drag-producing area, and loads within the airframe can be distributed over the entire wing to produce a lighter structure. Advances in computing capabilities allowed radar engineers to work out solutions for curved aircraft surfaces. The F-117 was very straight lined to deflect radar beams, but the ATB had to be designed with rounded airframe surfaces. Northrop was able to design the B-2 using radar-beam prediction programs. When designing a stealth aircraft, radar engineers try to make sure the aircraft will either absorb radar energy or deflect it away from the adversary's radar receiver.

New and improved radar-absorbing material allowed the external shape to be very smooth. The B-2's flying-wing configuration also made it possible to build an airframe without any protrusions, bury the engines in the wings, and eliminate the vertical stabilizer and control surfaces that normally add to an airframe's radar signature. By placing the engines into the wings and shielding the engine's turbine blades and engine air intakes from direct radar observation, more stealth is incorporated into the B-2. Since radar is not the only means by which a flying aircraft can be detected, the engine exhaust is mixed with cooler outside air to reduce the heat signature of the B-2. This makes it harder for an infrared guided weapon to target the bomber. Since all of the stealth design and engineering concepts used to reduce an aircraft's signature require tradeoffs, the secrecy surrounding a stealth aircraft is meant to not only protect the stealth technologies but also the choices and mixes made within the program design.

With the end of the Cold War and the corresponding cuts in defense spending, the B-2 program was also reduced. Only twenty-one aircraft, including a development model, were built for the United States. They are assigned to the 509th Bomb Wing at Whiteman Air Force Base in Missouri. They flew their first combat mission against Serbia in 1999 and since then have conducted sorties lasting up to forty-five hours to deliver precision-guided conventional munitions against Afghanistan and Iraq. Advanced avionics allow the B-2 to attack up to sixteen separate targets nearly simultaneously—that being the number of Joint Direct Attack Munitions (JDAM) or B-61 nuclear bombs the B-2's bomb bay can hold. New advanced munitions are constantly being fitted to the B-2's bomb bay: For example, the B-2 will carry up to 162 small-diameter bombs, each capable of hitting a separate target. The B-2 avionics also have been updated and communications systems improved to allow the bomb crew to reprogram its target coordinates while in flight to the target. The B-2 remains the most technologically advanced bomber in the world.

—Gilles Van Nederveen

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STOCKPILE STEWARDSHIP PROGRAM

The cessation of underground nuclear testing in the early 1990s created a major challenge for the U.S. Department of Energy (DOE): how to continue to certify the safety and readiness of its nuclear weapons without this key aspect of the annual certification program. Nuclear testing was the core activity that allowed DOE to certify to the president on an annual basis that the stockpile remained safe and capable. The replacement for the underground nuclear test program is the Stockpile Stewardship Program (SSP). (*See* Underground Testing.)

History and Background

Between July 1945 and September 1992, the United States conducted 1,054 nuclear weapons tests. In the early years of the program, testing allowed the United States to present its president with a nuclear option to end World War II. The arms race with the Soviet Union drove the need for future tests as the United States worked to stay ahead of Soviet scientists and the Soviet nuclear arsenal.

The collapse and breakup of the Soviet Union brought an end to this nuclear arms race. However, the Department of Energy was tasked to retain a nuclear deterrent capability, increase its efforts in nonproliferation of nuclear weapon technology, and ensure the United States was not surprised by nuclear arms developments elsewhere in the world.

The future of the nation's nuclear weapons program was changed in 1995 when President William Clinton announced that the United States would pursue a comprehensive nuclear test ban. The president also directed that necessary programmatic activities to ensure stockpile safety and reliability in the absence of nuclear testing be developed. The DOE Stockpile Stewardship Program was developed in response to this directive. In 1996, the president signed the Comprehensive Test Ban Treaty to end all nuclear testing. Although as of mid-2004 the United States had not ratified that treaty, it continues to abide by a unilateral moratorium on nuclear testing (*see* Comprehensive Test Ban Treaty; Department of Energy; Moratorium).

The Department of Energy's Stockpile Stewardship Program ensures that it can depend on experiments and simulations to predict, detect, evaluate, and correct problems affecting nuclear weapons without nuclear testing. Critical to meeting this challenge is the development of higher-resolution computer models of the performance of nuclear weapons and the conditions that affect weapon safety. This replaces the previous demonstration-based program with a science-based one that focuses on the implications to performance of an aging stockpile. The elements of SSP are located at the Lawrence Livermore, Los Alamos, and Sandia national laboratories. The first annual certification of the stockpile under the SSP was signed on February 7, 1997.

Technical Details

The SSP relies on the world's largest and fastest computers to conduct "virtual" nuclear tests using ever-improving computer codes. The increased resolution of these codes over time requires a steady stream of ever-improving, quality data. The data needs are being met by the construction and operation of special experimental facilities, each designed to provide unique data to the program. Examples of these facilities and capabilities follow.

The National Ignition Facility (NIF) is an experimental cornerstone of SSP, providing a unique data source for studying the physics of nuclear weapon primary and secondary components. The NIF is a laser facility on a massive scale. It will have 192 operational laser beams delivering nearly 2 megajoules of energy to the center of its chamber by 2008. It is the only facility that will conduct experiments to examine fusion burn and to study weapons-related processes at nuclear weapons–relevant energy density. By the end of 2005, 16 of its 192 beams will be operational, making it the world's largest laser with only 10 percent of its beams in operation. Although the NIF's primary role will be in support of stockpile stewardship, it will also serve as a national facility for basic research in high energy–density physics. When ignition is demonstrated in 2010, NIF will play a major role in fusion energy research. With congressional approval, Livermore is partnering on NIF with U.S. allies, particularly the French CEA Division Applications Militaire and the British AWE Ministry of Defense. Both countries have strong commitments to stockpile stewardship programs in which laser facilities play prominent roles.

The Accelerated Strategic Computing Initiative (ASCI) is a tri-laboratory DOE program that will dramatically advance the ability to simulate computationally the performance of an aging stockpile and conditions affecting weapon safety. Although it will take more than a decade to achieve ASCI's long-term goals of a ten-thousand-fold increase in computer speed and data storage capacity each year, the initiative is structured to deliver major new capabilities to support stockpile stewardship. Central to ASCI is the accelerated development over the next decade of highly parallel, tera-scale computers in partnership with the U.S. computer industry. A tera-scale computer performs a trillion operations per second, a thousandfold improvement over the 1998 capability. Computers of this size and speed are necessary to simulate the integrated details that were once tested in underground explosions. As part of the ASCI initiative, Livermore has partnered with IBM to develop these highly advanced computational capabilities. ASCI's computers of the future will face the challenge of providing accurate and detailed simulated predictions of the complex processes involved in nuclear weapons explosions as well as of the detailed materials changes in weapons due to aging and refurbishment. The success of SSP will depend on the credibility of the weapons laboratories' simulations, as measured by their ability to accurately predict complex laboratory experiments at facilities such as NIF at Lawrence Livermore or Dual Axis Radiation Hydrodynamics Test Facility (DARHT) at Los Alamos (*see* Lawrence Livermore National Laboratory; Los Alamos National Laboratory).

Weapons aging is a critical issue. Aging affects the physical characteristics of all materials, producing premature materials failure in airplanes, cars, and nuclear weapons. With a better understanding of aging, stockpile surveillance can become more predictive, making possible systematic refurbishment and preventive maintenance activities that can correct problems that threaten weapon safety or reliability. With fewer weapons and fewer types of weapons in the stockpile, together with reduced capabilities and capacity in the production complex, DOE must become more and more proficient at detecting and predicting potential problems early on to provide enough time for thorough evaluation and action before problems affect stockpile safety or reliability. The national laboratories are improving their databases on the characteristics and behavior of stockpiled weapons so that they can identify anomalies in aging weapons. They are improving sensors and techniques used to inspect stockpiled weapons, and they are developing a better understanding of how aging alters the physical characteristics of weapon materials and how these changes affect weapon reliability and safety.

The Contained Firing Facility (CFF) at Lawrence Livermore is a modern capability for studying the dynamic implosion of simulated weapons using high explosives. These dynamic simulations are known as explosive hydrodynamics tests. In the absence of nuclear testing, explosive hydrodynamics tests are the principal experimental means of assessing the integral performance of primaries in stockpile nuclear weapons. Testing is conducted in a large containment chamber with an automatic washdown system for rapid experiment turnaround. CFF has increased radiographic dose over earlier facilities, improved resolution, and added a double-pulsing mode to support dynamic radiography. CFF is the principal source of the high-fidelity measurements of primary performance needed to preserve confidence in the integrity of stockpile weapons.

Tritium is used to boost nuclear weapon yields. No tritium has been produced for the U.S. weapons stockpile since 1988. DOE is meeting stockpile needs by recycling tritium from dismantled weapons. Since tritium decays at a rate of 5.5 percent per year, the total tritium inventory available without further production will decline to a level where, by 2007, the inventory will be insufficient to maintain a START II stockpile. The new Accelerator Production of Tritium (APT) program will use a high-energy, high-current proton accelerator to produce tritium. The DOE's national security laboratories are designing the APT facility, with Los Alamos as the lead laboratory (*see* Tritium).

The DOE national security laboratories are working closely with the production plants to maintain the enduring U.S. stockpile through a combination of as-needed repairs, refurbishments, and replacements. Workforce skills, formerly developed and maintained through new weapons development, also must be maintained through this repair-refurbish-replace process. DOE's Advanced Design and Production Technology (ADaPT) program is a complex-wide effort to meet these challenges. The program integrates the skills and facilities of the national security laboratories and the production plants to develop innovative new processes and practices that will be needed to achieve a requirements-based, cost-effective production complex.

The Future

DOE and its national laboratories are focusing their best talents on defining the key SSP scientific challenges. These challenges include vastly increased computational capabilities, a much deeper understanding of materials processes (from the atomic to the macroscopic level), major improvements in the ability to model complex nonlinear dynamic processes, and experimental facilities that can produce plasma density and pressure regimes well beyond any available in the world today. The scientific infrastructure that will support SSP, now and in the future, depends on a myriad of small experimental facilities compiling data that provide single pieces of the large jigsaw puzzle. All are working to ensure that these capabilities in physics, chemistry, and other basic sciences, as well as their theoretical counterparts, remain a robust and productive mainstay of stockpile stewardship.

—*Don Gillich*

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STRATEGIC AIR COMMAND (SAC) AND STRATEGIC COMMAND (STRATCOM)

On March 21, 1946, the U.S. Strategic Air Command (SAC) was formed with the mission of deterring aggression by maintaining the ability to conduct long-range offensive missions throughout the world and maximum-range reconnaissance over land and sea. The United States depended on SAC to plan and conduct long-range nuclear attacks against the Soviet Union as the basis of its Cold War deterrent. SAC housed the Joint Strategic Target Planning Staff, responsible for building the U.S. nuclear war plan, the Single Integrated Operational Plan (SIOP).

With the end of the Cold War, on June 1, 1992, SAC was restructured and renamed U.S. Strategic Command (STRATCOM). The purpose of the restructuring was to downsize and consolidate all U.S. nuclear forces under one commander to improve efficiency in maintaining the U.S. nuclear deterrent.

History and Background

SAC, along with the U.S. Air Force, was created in the aftermath of World War II and was intended to develop the nascent U.S. nuclear capability into a credible deterrent force. General George C. Kenney was the first commander of SAC and assembled 100,000 personnel and 1,300 aircraft under his command. Originally, SAC's headquarters was at Andrews Air Force Base, Maryland, and it operated eighteen air bases throughout the United States.

SAC grew rapidly in the early years of the nuclear age to a force of more than 224,000 personnel under the command of General Curtis E. LeMay (1948–1957). Under General Thomas S. Powers, SAC's third commander, SAC began to maintain bombers on ground alert. The ground-alert concept allowed SAC to maintain almost one-third of its aircraft with weapons loaded and crews prepared for immediate launch to bolster U.S. second-strike capabilities. It was a response to advances in Soviet rocketry that threatened the survivability of the U.S. strategic bomber force. General Powers also was responsible for creating SAC's motto, Peace Is Our Profession, demonstrating his belief that the command succeeded only if it never had to execute its nuclear attack missions (*see* Airborne Alert, Second Strike).

Throughout the 1950s, SAC received 47 percent of the entire U.S. military budget. There were three reasons why SAC became the primary U.S. command and received the most money: SAC constituted the primary U.S. deterrent against the Soviets; it owned two-thirds of the nuclear "Triad" (the B-52 bombers and ballistic missiles); and it had the strategic war planning system to build the SIOP (*see* Single Integrated Operational Plan).

In addition to its nuclear alert mission, beginning in the early 1970s SAC began exercising its bomber force in conventional conflicts. During the Vietnam War, SAC aircraft and crews participated in the bombing of both North and South Vietnam. During Desert Storm, SAC utilized its B-52 bombers in a conventional role against dug-in Iraqi armor and infantry units. SAC tanker aircraft also played a significant role during Desert Storm by refueling both long-range bombers and fighter aircraft as they conducted missions over Kuwait and Iraq.

From SAC to STRATCOM

STRATCOM was formed on June 1, 1992, as the single joint command of all U.S. nuclear forces: land- and sea-based ballistic missiles, submarines, tankers, bombers, and airborne command posts. The mission of STRATCOM is to deter a major military attack on the United States and its allies and, if necessary, employ strategic forces to halt and win a conflict. There are five command goals: (1) to establish STRATCOM as the leading authority on strategic matters; (2) to develop force employment plans and develop a role in defense planning; (3) to develop capabilities and position forces to meet strategic objectives; (4) to effectively call on assigned forces in strategic operations; and (5) to uphold a strong and cooperative relationship with other agencies. The president and the secretary of defense direct STRATCOM's missions, which range from deterring attacks by maintaining missiles, bombers, and submarines on alert to preparing the nation's nuclear war plan. STRATCOM also performs worldwide strategic reconnaissance. Additionally, it maintains and controls the communications and intelligence support networks linking all military forces, which are ready to respond 24 hours a day, 365 days a year.

Today, STRATCOM plays a leading role in creation of the new nuclear Triad (a revitalized partnership of an enhanced nuclear infrastructure, missile defenses, and a mix of conventional and nuclear strike forces) outlined in the 2001 Nuclear Posture Review. The deliberate planning formerly practiced by the Joint Strategic Target Planning Staff during the Cold War has been replaced by adaptive, "capabilities-based" planning. Additionally, STRATCOM is at the forefront of integrating conventional global-strike and nuclear forces, strategic defenses, and advanced operating concepts to create credible deterrence options and force structure for the twenty-first century (*see* Nuclear Posture Review).

—*Laura Fontaine*

See also: Ballistic Missiles; Bombers, U.S. Nuclear-Capable; Nuclear Posture Review; Single Integrated Operational Plan; United States Air Force; United States Nuclear Forces and Doctrine

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STRATEGIC ARMS LIMITATION TALKS (SALT I AND SALT II)

The Strategic Arms Limitation Talks (SALT) were bilateral discussions between the United States and the Soviet Union on limiting the nuclear arms race. SALT I (November 1969 to January 1972) yielded two agreements, the Anti-Ballistic Missile (ABM) Treaty and the Interim Agreement on the Limitation of Strategic Offensive Arms. SALT II (September 1972 to January 1979) resulted in the Vladivostok Accord and the SALT II Treaty.

History and Background

Following several unsuccessful attempts to achieve complete disarmament, the United States proposed a new approach at the United Nations' Eighteen-Nation Disarmament Committee in January 1964, suggesting that the United States and the Soviet Union should explore a verified freeze of the number, types, and capabilities of their strategic nuclear offensive and defensive vehicles. The Soviets rejected the gesture and by 1966 had begun to deploy an antiballistic missile defense around Moscow. That same year, China successfully tested a nuclear missile. In September 1967, the United States announced that it would begin deployment of a "thin" antiballistic missile (ABM) system to defend against an extremely modest Chinese intercontinental ballistic missile (ICBM) threat and the remote possibility of an accidental launch of an intercontinental missile by a nuclear-armed state.

At the July 1968 signing of the Nuclear Nonproliferation Treaty (NPT), U.S. president Lyndon B. Johnson announced that an agreement had been reached with the Soviet Union to begin discussions on limiting and reducing both strategic nuclear weapons delivery systems and defense against ballistic missiles.

In addition to the issues of trust and hostility to be expected in any adversarial relationship, negotiation was further complicated by the differing needs and goals of each side. The Soviet Union was contiguous with its principal allies, but the United States was geographically distant from its allies in Western Europe and Japan. The geographic issue was indeed complicated, as the Soviets wished to limit all missiles capable of hitting the other side's territory—which would have included Western weapons in Western Europe, including those launched from bombers and aircraft carriers—whereas the United States desired to include only intercontinental ballistic missiles.

Designing a verification regime was also a difficult task because, for obvious reasons of secrecy, neither side could permit the other free access to its territory, let alone its military facilities. Eventually, they agreed to "national technical means of verification" (mainly, satellites deployed in orbit) and promised not to use deliberate concealment to impede verification using these means. Neither of these measures proved satisfactory, however, and both sides routinely accused the other of cheating throughout the life of the SALT treaties (*see* National Technical Means; Telemetry).

Although the Interim Agreement expired after five years, the ABM Treaty was of "unlimited duration" but granted each party the right to withdraw six months after giving notice if it determined that the strategic situation had changed to the point where adhering to the treaty put its vital interests in danger. The United States activated this clause in December 2001 and withdrew from the ABM Treaty in May 2002.

Negotiations on SALT II began in November 1972 with the aim of creating a permanent framework to replace the Interim Agreement. At a meeting in Vladivostok, Siberia, in November 1974, President Gerald Ford and General Secretary Leonid Brezhnev agreed to a Basic Framework for the SALT II agreement: an equal aggregate limit of 2,400 strategic nuclear delivery vehicles (ICBMs, submarine-launched ballistic missiles [SLBMs], and heavy bombers); deployment of up to 1,300 multiple independently targetable reentry vehicles (MIRVs); a ban on construction of new land-based ICBM launchers; and limits on the deployment of new types of strategic offensive arms. They agreed that these limits would last through 1985. Negotiations stalled in early 1975, however, owing to numerous disagreements. These were over whether the new

Soviet bomber known to the United States as "Backfire" would be considered a heavy bomber and therefore included in the 2,400 aggregate; the MIRV verification process; missile throw weight ceilings; and the status of cruise missiles.

The talks received a renewed emphasis during the administration of President Jimmy Carter. Ultimately, the parties resolved or agreed to defer resolution of the sticking points until SALT III (which never occurred). The SALT II Treaty was signed by President Carter and General Secretary Brezhnev in Vienna on June 18, 1979, and transmitted to the Senate for ratification four days later. On January 3, 1980, following the Soviet invasion of Afghanistan, President Carter requested that the Senate shelve discussion of the treaty rather than allowing it to be voted down by the U.S. Senate.

Although the treaty was never formally ratified, both sides were bound under international law to comply with its broad outlines until they formally announced their intention to withdraw from the agreement. Carter pledged to allow the terms to remain in force as long as the Soviet Union reciprocated, and Brezhnev made a similar statement. President Ronald Reagan initially pledged to abide by the terms of the treaty when he took office in 1981. He declared in 1984, and again in 1985, that the Soviets had violated several provisions but that the United States would nonetheless continue to work within the interim framework. On May 26, 1986, however, he submitted three detailed reports to Congress describing major violations by the Soviets and announced that the United States would henceforth base decisions about its strategic force structure on the nature and magnitude of the threat posed by Soviet strategic forces and not on the limits outlined by the SALT structure. Ultimately, the Reagan administration did not increase strategic force levels beyond SALT II levels and, finding a more cooperative government under Soviet president Mikhail Gorbachev, obviated the treaty by negotiating two agreements that actually further reduced nuclear force levels on both sides: the Intermediate-Range Nuclear Forces (INF) Treaty and the Strategic Arms Reduction Treaty (START I).

The Arms Race Continues

Soviet and U.S. weapons systems were far from symmetrical in the late 1960s. The Soviet Union had continued its development and deployment of heavy ballistic missiles and had overtaken the U.S. lead in land-based ICBMs. During the SALT I years alone, the number of Soviet ICBMs rose from around 1,000 to 1,500, and they were being deployed at the rate of some 200 annually. Soviet submarine-based launchers had quadrupled. The huge payload capacity ("throw weight") of some Soviet missiles was seen as a possible threat to U.S. land-based strategic missiles even in heavily protected ("hardened") missile silos.

The United States had not increased its deployment of strategic missiles since 1967 (when its ICBMs numbered 1,054 and its SLBMs 656), but it was conducting a vigorous program of equipping missiles with MIRVed warheads. MIRVs permit an individual missile to carry a number of warheads directed at separate targets. They thus gave the United States a lead in the number of nuclear warheads deployed as part of its strategic arsenal. The United States also retained a lead in long-range bombers. The Soviet Union had a limited ABM system around Moscow; the United States had shifted from its earlier plan for a "thin" ABM defense of certain U.S. cities and instead began to deploy ABMs at two land-based ICBM missile sites to protect its retaliatory forces. (The full program envisaged twelve ABM complexes.)

Current Status

These treaties are no longer in force. SALT I's Interim Agreement was for a period of five years and thus expired in 1979. SALT II was never ratified by the U.S. Senate, although its provisions were informally adhered to by successive presidential administrations until the treaty was eventually rendered moot by START I and II. The United States announced its withdrawal from the ABM Treaty December 13, 2001.

The United States and Russia continue to have dialogues on nuclear weapons, most notably leading to the May 2002 Moscow Treaty on strategic offensive reductions. With the end of the Cold War, however, the principal concern has shifted from a nuclear arms race on both sides to how to manage existing stockpiles and prevent proliferation to outside parties.

—James Joyner

See also: Arms Control; Missile Defense; Strategic Offensive Reductions Treaty

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STRATEGIC ARMS REDUCTION TREATY (START I)

The Strategic Arms Reduction Treaty (START I), officially the Treaty on the Reduction and Limitation of Strategic Offensive Arms, was an agreement between the United States and the Soviet Union signed by Presidents George H. W. Bush and Mikhail Gorbachev in Moscow on July 31, 1991. START I was a product of nine years of negotiations and entered into force on December 5, 1994. Its terms provided for reductions in strategic offensive arms to equal aggregate levels to be carried out in three phases over seven years. These were specific, equal interim levels for agreed categories of strategic offensive arms by the end of each phase. At the end of the seven-year period, central limits included: 1,600 strategic nuclear delivery vehicles (SNDVs); 6,000 accountable warheads; and 4,900 ballistic missile warheads. The Soviets were also limited to 1,540 warheads on 154 heavy intercontinental ballistic missiles (ICBMs). Although the treaty allows for existing equipment to be modernized or replaced, it bans the production, flight testing, and deployment of new or modified ICBMs and submarine-launched ballistic missiles (SLBMs) with more than ten warheads. Under START I, U.S. long-range nuclear weapons were cut by 15 percent, while Soviet/Russian strategic forces were cut by 25 percent.

History and Background

During the run-up to presidential elections in 1980, Republican candidate Ronald Reagan had called the unratified treaty resulting from the Strategic Arms Limitation Talks (SALT II) "fatally flawed" and promised that if elected he would withdraw the treaty from the Senate. He opposed the treaty on the grounds that it did not limit throw weight, the true measure of destructive power, and did not close what he called the "window of vulnerability" that the United States faced, which he believed was caused by the fleet of heavy Soviet ICBMs that were theoretically capable of destroying the U.S. ICBM force in a first strike. After taking office, however, the Reagan administration announced that although it was reviewing U.S. arms control policy, it would not undercut the provisions of the SALT II Treaty.

In November 1981, Reagan announced that new strategic arms talks, now called Strategic Arms Reduction Talks, could possibly begin the following year, and that the goal for negotiators would be to reduce strategic nuclear arms. Meanwhile, negotiations on intermediate-range nuclear forces (INF) had already begun in 1981. With the introduction of nuclear-freeze resolutions in the House of Representatives and the Senate, Reagan came under increasing domestic pressure in March 1981 to initiate negotiations. On March 31, 1982, during his first prime-time news conference, the president invited the Soviet Union to join the United States in negotiations to reduce the size of both nuclear arsenals.

START negotiations began in Geneva on June 29, 1982. By the end of 1989, many of the treaty's basic provisions had been designed. The Reykjavik Summit meeting of October 11–12, 1986, the Foreign Ministers meeting of September 15–17, 1987, the Washington Summit meeting of December 7–10, 1987, and the Wyoming Foreign Ministers meeting of September 22–23, 1989, led to agreement on most of these provisions. Important progress was made at the Wyoming Foreign Ministers meeting. U.S. negotiators were able to prevent any linkage between reductions of strategic offensive nuclear weapons and the Reagan administration's plan to pursue space-based defenses against ballistic missiles. In addition, the Soviet Union agreed to dismantle, without preconditions, the phased-array Krasnoyarsk radar, which violated the 1972 Anti-Ballistic Missile (ABM) Treaty.

Other issues that had previously defied solution at the negotiating table, however, had to be addressed in the treaty. Negotiators had to determine counting rules for heavy bombers carrying nuclear-armed air-launched cruise missiles (ALCMs), a sublimit on ICBM warheads, sublimits on warheads on mobile ICBMs, and counting rules for nondeployed missiles. They had to resolve problems concerning the modernization of heavy ICBMs and determine how to address nuclear sea-launched cruise missiles (SLCMs), telemetry encryption, and cuts in Soviet missile throw weight. Finally, they had to design an effective verification regime to monitor treaty compliance.

After nine years of negotiations, the START team experienced a frenetic pace of activity in the six weeks before it was signed. During this time, negotiators came to an agreement on the three remaining issues: warhead downloading, accountability for new types of missiles, and data denial. Conclusive negotiations centered on counting rules within agreed limits and sublimits for both nuclear delivery vehicles and warheads. The agreement represented the first time in U.S.-Soviet arms control history that the two nations had decided to make deep cuts in their respective nuclear arsenals. Unlike the Intermediate-Range Nuclear Forces (INF) Treaty of 1987, however, START I did not require elimination of an entire category of nuclear weapons. At the Group of Seven Summit in London on July 17, 1991, Presidents George H. W. Bush and Mikhail Gorbachev announced that START was ready to be signed at a U.S.-Soviet summit in Moscow by the end of that month (*see* Telemetry).

The Treaty

START I consists of nineteen articles governing basic provisions, two annexes, six protocols, a memorandum of understanding, and several associated documents (joint statements, unilateral statements, declarations, and an exchange of letters) meant to amplify and define basic treaty provisions and facilitate their implementation. The treaty limits the total number of SNDVs that each side can possess to 1,600, the total number of accountable warheads to 6,000 each, the total number of warheads mounted on ballistic missiles (ICBMs and SLBMs) to 4,900 each, and the total ballistic missile throw weight for each side to 3,600 metric tons. START I also permits the Soviet (Russian) side to have no more than 154 “heavy” ICBMs (defined as having launch weight greater than 106 tons or a throw weight greater than 4,350 kilograms). This specifically applies to the R-36M series (NATO designation: SS-18 Satan) ICBM. No more than 1,540 warheads can be mounted on these missiles. The treaty also bans the construction of new types of heavy ICBMs and SLBMs. It permits modernization programs and, in exceptional cases, new silo construction. The testing of missiles with a greater number of warheads than declared in the treaty is banned by the treaty. New ballistic missiles with more than ten warheads are also banned. Although parties to the treaty may also reduce the number of warheads attributed to a specific missile, no more than three existing missile types may have the number of warheads reduced, and the total reduction may not exceed 1,250 warheads. New missile types or heavy ICBMs may not be downloaded.

START I counted each ICBM and SLBM reentry vehicle as a single warhead. Counting rules for warheads attributed to heavy bombers were more complicated. Each Soviet/Russian heavy bomber equipped to carry long-range nuclear ALCMs (defined as having a maximum range of at least 600 kilometers), up to a total of 180 bombers, counted as eight warheads toward the 6,000-warhead limit, even though existing Russian heavy-bomber types could carry between six and sixteen ALCMs. For each Russian heavy bomber above the level of 180, the actual number of ALCMs counted toward the 6,000-warhead limit. In the same way, each U.S. long-range nuclear ALCM-carrying heavy bomber, up to a total of 150 bombers, counted as ten warheads toward the 6,000 warhead limit, and for each bomber in excess of 150, the actual number of ALCMs it could carry counted toward the warhead limit. Bombers not equipped to carry long-range nuclear ALCMs were counted as one warhead.

Extensive provisions for verification were provided for in START I and included the use of national technical means (NTM), missile test telemetry tape exchanges, periodic data exchanges, monitoring activities, and on-site inspections (OSIs). The U.S. On-Site Inspection Agency (OSIA) (now part of the Defense Threat Reduction Agency) and the Russian Nuclear Risk Reduction Center (NRRC) implement on-site inspection and escort activities under the treaty. The treaty has a duration of fifteen years unless superseded by another agreement. The parties can agree to extend the treaty for successive five-year periods, but each party has the right to withdraw from it at any time if it decides that extraordinary events have jeopardized its supreme interests (*see* Defense Threat Reduction Agency [DTRA]; National Technical Means; Nuclear Risk Reduction Centers; On-Site Inspection Agency; Verification).

The Lisbon Protocol and Ratification Issues

Following the end of the Soviet era in December 1991, nuclear arms were still deployed in some ex-Soviet republics. Four states now had nuclear weapons based on their territories—Russia, Belarus, Kazakhstan, and Ukraine. The three republics and the Russian Federation undertook to make arrangements among themselves for the implementation of the treaty's provisions at a May 23, 1992, ministerial meeting in Lisbon, Portugal. The United States, Russia, Belarus, Kazakhstan, and Ukraine signed a protocol, known as the Lisbon Protocol, to the treaty making all five countries signatories of START I. Under the protocol, Belarus, Kazakhstan, and Ukraine agreed to eliminate all nuclear weapons on their territory and to join the 1968 Nuclear Nonproliferation Treaty (NPT) as non–nuclear weapons states (NNWS). Russian ratification of START I hinged on this pledge. Thus, though START I was initially a bilateral treaty between the Soviet Union and the United States, the Lisbon Protocol transformed it into a multilateral treaty that was later ratified as a bilateral treaty between Russia and the United States (*see* Nuclear Nonproliferation Treaty [NPT]).

START I was ratified by the U.S. Senate on October 1, 1992. The Russian Parliament ratified it on November 4, 1992; Kazakhstan ratified it on July 2, 1992, and deposited the instruments of accession to the NPT on February 14, 1993. Ukraine became the last former Soviet republic to ratify the treaty on November 18, 1993. The Ukrainian Parliament approved a resolution on November 16, 1994, to accede to the NPT as a non–nuclear weapons state. President Leonid Kuchma of Ukraine deposited the NPT instruments of ratification at a ceremony on December 5, 1994, held at the Conference on Security and Cooperation in Europe (CSCE) summit meeting in Budapest, Hungary, paving the way for a second ceremony on the same day where leaders of the five Lisbon Protocol signatory countries signed a protocol exchanging the START I instruments of ratification. Baseline inspections began on March 1, 1995, when three ten-member teams from OSIA arrived in Russia from the United States. The teams, which had to be allowed onto a base within twenty-four hours of giving notice, had a schedule of visiting seventy-one weapons facilities in Belarus, Kazakhstan, Russia, and Ukraine.

Results

On December 5, 2001, seven years after the accord entered into force, the United States and Russia completed their weapons reductions as provided for by the terms of START I, thus completing the largest arms control reductions in history. The treaty will remain in effect until December 5, 2009. During this time, the treaty parties can request challenge inspections of suspect activity. Also, the two countries have the option of extending the accord for successive five-year periods if the treaty has not been superseded by another arms reduction agreement.

Since exchanging baseline stockpile information in September 1990, the two countries have reduced their strategic nuclear arsenals by more than 40 percent over the past decade. The shortcomings of the treaty include the fact that START I does not require the destruction of nuclear warheads removed from delivery vehicles, which leaves the United States and Russia with a considerable number of warheads. The U.S. strategic and tactical warhead "hedge" is estimated at more than 5,000 warheads, and Russia is estimated to have stockpiled more than 13,000 warheads. Also, the accord does not cover nonstrategic nuclear weapons. Russia is estimated to have deployed between 3,500 and 15,000 tactical nuclear weapons, whereas the United States currently has a much smaller number of nuclear gravity bombs in storage in Europe and within its territory.

—Kalpana Chittaranjan

See also: Arms Control; Hedge; Presidential Nuclear Initiatives; Strategic Arms Limitation Talks; Strategic Arms Reduction Treaty

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STRATEGIC ARMS REDUCTION TREATY (START II)

The Strategic Arms Reduction Treaty (START II), officially entitled the Treaty on Further Reduction and Limitation of Strategic Offensive Arms, is an agreement between the United States and Russia signed by U.S. president George H. W. Bush and Russian president Boris Yeltsin in Moscow on January 3, 1993. The treaty established a limit on strategic weapons for each side, with reductions to be implemented in two phases. START II aimed to reduce the deployed strategic nuclear forces of both nations to 3,000 to 3,500 warheads (down from 6,000 warheads allowed under START I). Additional limits include a ban on multiple independently targetable reentry vehicles (MIRVs) on intercontinental ballistic missiles (ICBMs), the elimination of all SS-18 "heavy" missiles, a sublimit of 1,700 to 1,750 submarine-launched ballistic missile (SLBM) warheads (about one-half the SLBM warheads authorized for the United States under START I), and the freedom to "download" (remove) warheads from strategic missiles in order to meet required reductions (this could be done by "deMIRVing" ICBMs). START II also allowed no discount for heavy bomber weapons (the number of weapons counted for heavy bombers, in other words, would be the number they are actually equipped to carry). The treaty, however, did give the parties the right to "reorient" bombers capable of carrying nuclear weapons to conventional missions (and thus exempt them from the overall limits). Up to 100 heavy bombers could be transferred to conventional missions, provided they had never been equipped to carry long-range nuclear air-launched cruise missiles (ALCMs).

Phase I of the treaty was to be implemented within seven years of the entry into force of START I, and Phase II was to be implemented by January 1, 2003. These deadlines were extended to December 31, 2004, and December 31, 2007, by a protocol to the treaty signed by U.S. and Russian representatives on September 27, 1997.

History and Background

After START I, critics charged that the main shortcoming of the treaty was that it ultimately produced insufficient arms reductions. Thus, efforts were made to reach a more comprehensive arms control treaty between the United States and Russia. President George H. W. Bush's State of the Union address to the U.S. Congress on January 28, 1992, contained a proposal for a new agreement requiring far deeper cuts than those required by the provisions of START I. In a statement of what was to become the basic provisions of START II, the president said, "I have informed President Yeltsin that if the [former Soviet republics] will eliminate all land-based multiple-warhead ballistic missiles . . . [w]e will eliminate all Peacekeeper missiles. We will reduce the number of warheads on Minuteman missiles to one, and reduce the number of warheads on our sea-based missiles by about one-third. And we will convert a substantial portion of our strategic bombers to primarily conventional use." Russian president Boris Yeltsin responded the next day with a proposal of his own, in which he suggested that the two sides cut their strategic nuclear warheads to 2,000–2,500 each.

Ministerial meetings between U.S. secretary of state James Baker and his Russian counterpart, Foreign Minister Andrei Kozyrev, were held to discuss these proposals in February, March, May, and June 1992. These negotiations paved the way for presidents Bush and Yeltsin to hold a summit meeting on June 16–18, 1992, in Washington, D.C. At the summit, the two presidents developed the framework for a follow-on Strategic Arms Reduction Treaty (START II), symbolized by their "Joint Understanding on Further Reductions in Strategic Offensive Arms." This agreement included numerical ceilings and a time frame for reductions. The "Joint Understanding" called for elimination of all MIRVed ICBMs, a limit of 1,750 on SLBM warheads, counting rules whereby bombers count as "the number of warheads they are actually equipped to carry," and reductions by both sides to between 3,000 and 3,500 warheads by 2003.

Telephone calls exchanged between Bush and Yeltsin on December 20 and 21, 1992, produced more progress on an agreement, and a team of U.S. and Russian specialists met in Geneva on December 22–24 to work on specific points of disagreement. At high-level meetings in Geneva on December 28 and 29 between the U.S. secretary of state and Russian foreign and defense ministers, the last issues were finally resolved. When presidents Bush and Yeltsin signed the START II agreement on January 3, 1993, they concluded the most sweeping nuclear arms reduction agreement in history and the first post–Cold War arms control treaty between the United States and Russia.

The Treaty

The treaty itself consists of eight articles, two protocols, and a memorandum of understanding. It requires the United States and Russia to eliminate their MIRVed ICBMs and reduce the number of their deployed strategic nuclear warheads to 3,000–3,500 each. The treaty complements rather than replaces START I in that the earlier treaty's provisions remain unchanged unless specifically modified by START II. START II is to remain in force for the duration of START I.

Each side made the commitment to reduce the total number of its strategic nuclear warheads to 3,000–3,500 by the end of Phase II. (This limit has now been superseded by the May 2002 Moscow Treaty, which limits Russia and the United States to no more than 1,700–2,200 warheads by 2012; see Strategic Offensive Reductions Treaty [SORT].) Of the retained warheads, none can be on MIRVed ICBMs, including heavy ICBMs. Only ICBMs carrying a single warhead are allowed by the treaty. START II would enter into force on the date of exchange of instruments of ratification but not before the entry into force of START I. Since START II builds upon START I, it must remain in force throughout the duration of the latter. As in START I, each side has the right to withdraw from the treaty if it decides that extraordinary changes in the international security environment have jeopardized its supreme interests. Like START I, START II would be verified by on-site inspections. Heavy bomber conversions to conventional roles, missile elimination, and silo conversions would be subject to inspection. Before START II could enter into force, three requirements had to be fulfilled: (1) START I had to enter into force; (2) the U.S. Senate had to ratify the treaty; and (3) the Russian Parliament had to ratify the treaty.

Follow-Up

START I entered into force on December 5, 1994, and the United States and Russia completed the terms of this treaty seven years later, on December 5, 2001. On January 26, 1996, the U.S. Senate approved a resolution of ratification of START II by a vote of 87–4. Russian ratification of the treaty, however, was a long-drawn affair. U.S. secretary of defense William Perry visited Moscow to address the Duma on October 17, 1996, in an attempt to persuade Russian legislators to ratify START II. But his words apparently had little impact on the Russian lower house. On April 9, 1997, the Russian Duma voted to postpone debate over ratification of the treaty.

Although the treaty remained unratified, both U.S. and Russian officials continued to update its provisions to better meet changing circumstances. In the Helsinki Summit held on March 21, 1997, for instance, U.S. president Bill Clinton and Russian president Yeltsin issued a "Joint Statement on Parameters on Future Reductions in Nuclear Forces" in which, regarding START II, they agreed to extend the elimination deadline for strategic nuclear delivery vehicles from January 1, 2003, to December 31, 2007, and to deactivate immediately all strategic nuclear delivery vehicles scheduled for elimination by December 31, 2003. On September 27, 1997, the extension of these time frames was incorporated into a protocol, which was signed by representatives from both countries.

Political disputes related to the various global events further delayed Russian ratification of the treaty. The Duma postponed its planned ratification vote of START II in December 1998 to signal displeasure with U.S. and British air strikes against Iraq. Air strikes again emerged as a stumbling block to Russian START II ratification when the start of the North Atlantic Treaty Organization's campaign against Yugoslavia forced the Russian prime minister Yevgeny Primakov on March 26, 1999, to ask the Duma to postpone consideration of the treaty yet again.

Current Status

Seven years after the treaty was signed, on April 14, 2000, the Duma finally ratified START II (but with crucial reservations) by a vote of 288–131. Under Article II of the Duma's ratifying legislation, deputies approved motions that allowed Russia to abandon its arms control agreements if the United States violated the ABM Treaty by deploying national missile defenses. The Duma vote also required the U.S. Senate to approve several additional documents as part of the START II package before instruments of ratification could be exchanged and the treaty could enter into force. These documents included two controversial additional protocols on the issue of the demarcation of theater missile defense and national missile defense interceptors. The Russian upper house of Parliament supported the Duma's resolution 122–15. Russian president Vladimir Putin signed this legislation on May 4, 2000, to ratify the treaty.

The U.S. Senate Ratification Resolution includes a provision that requires the president to seek Senate approval of any strategic arms cuts that would reduce the U.S. strategic arsenal to below START I ceilings before START II enters into force. The Russian START II ratification law requires the U.S. Senate to ratify the START II Extension Protocol and the 1997 ABM Agreements, which clarified the demarcation between theater and strategic missile defenses, so that ratification instruments may be exchanged for these documents, before START II enters into force. However, the U.S. Senate has not taken up either of these matters for consideration.

As a response to the U.S. withdrawal from the ABM Treaty on June 13, 2002, Russia declared the next day that it would no longer be bound by the START II nuclear arms reduction agreement. Analysts have concluded that Moscow's announcement of treaty withdrawal is more symbolic than substantive because START II had never come into force and was unlikely to have ever taken effect after Russia had tied its fate to that of the ABM Treaty in April 2000. According to a U.S. official, the collapse of START II has not upset the George W. Bush administration, as the United States and Russia have already "moved beyond" the agreement with the signing of the Moscow Treaty of May 24, 2002. If this treaty enters into force, it will commit each country to limiting its deployed strategic nuclear forces to fewer than 2,200 warheads by the end of 2012. Although international law requires countries not to undermine the object of treaties they have signed, even if those treaties have not entered into force, the Russian statement of June 2002 suggests that the Russians no longer consider themselves legally obligated to refrain from actions forbidden by START II.

—*Kalpana Chittaranjan*

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STRATEGIC DEFENSE INITIATIVE (SDI)

The Strategic Defense Initiative (SDI) was a ballistic missile defense (BMD) research and development program launched by President Ronald Reagan in 1983. SDI was not the first BMD program undertaken by the United States, nor would it be the last. But SDI did become one of the most well-known and controversial missile defense proposals ever introduced by a U.S. administration. Its arrival came amid a growing global antinuclear movement and political changes in the Soviet Union, both of which added to the program's controversial reputation. Critics derided SDI as "Star Wars," but some supporters eventually came to embrace the moniker as well, finding inspiration in the technological and political idealism of the program.

After Reagan left office, SDI suffered from the decoupling of its mission from its charismatic creator as well as from its failure to produce effective technology. Presidents George H. W. Bush and Bill Clinton took steps to downsize SDI's ambitious mission to smaller-scale BMD goals. Bush added the space-based "Brilliant Pebbles" layer to the plan, and Clinton eventually reorganized SDI's bureaucratic home, the Strategic Defense Initiative Organization, into the theater missile defense–focused Ballistic Missile Defense Organization. President George W. Bush, drawing in part on Reagan's elaborate vision for missile defense, however, reorganized U.S. missile defense programs once again in 2001 into the Missile Defense Agency (MDA). The latter Bush, in some respects inspired by Reagan's SDI vision, tasked the MDA with piecing together a broad and layered defense. Although "Star Wars" joined previous U.S. BMD programs in failing to yield an effective defense, its legacy is represented in these later reorganizations. But its legacy survives as well in the nation's consciousness—the program encapsulated Reagan's political clarity between good and evil while feeding his opponents' worries over the costs of unilateral and unchecked U.S. hegemony. These motivations and divisions remain key factors of the BMD debate today.

History and Background

Several developments between the cancellation of the Safeguard program in the mid-1970s and the 1983 creation of SDI led Reagan to start the program he hoped would make nuclear weapons "impotent and obsolete" (*see* Safeguard Antiballistic Missile [ABM] System). As a presidential candidate, Reagan toured the North American Air Defense Command and was concerned that a computer simulation he saw there of a nuclear attack on U.S. targets showed no option for the military to defend against them. As president, Reagan became further intrigued by missile defense when he could not find a workable basing mode for the MX intercontinental missiles designed to guarantee retaliation against a Soviet attack. In February 1983, the Joint Chiefs of Staff recommended that the United States place a greater emphasis on developing missile defenses. With supportive advice from renowned nuclear weapons physicist Edward Teller, Reagan publicized his plan in an historic March 23, 1983, speech to the nation. Reagan struck a visionary and utopian tone, asking the country, "What if free people could live secure in the knowledge that their security did not rest on the threat of instant U.S. retaliation to deter a Soviet attack; that we could intercept and destroy strategic ballistic missiles before they reached our own soil or that of our allies?" The president acknowledged the technological challenges to such a dream but framed the debate as a test to the nation's scientists—whom he called those "who gave us nuclear weapons"—to make the world more secure.

Architects of the system hoped to incorporate a variety of land-, air-, sea-, and space-based weapons to intercept incoming Soviet ballistic missiles. Although the 1972 Anti-Ballistic Missile (ABM) Treaty limited deployment of such systems, the administration believed testing these proposed systems would not violate the agreement with the Soviet Union. Reactions differed and often broke down along predictable lines—supporters in conservative circles welcomed the chance to break free of offense-based nuclear deterrence, whereas opponents in the burgeoning nuclear freeze movement and elsewhere on the left remained skeptical of both Reagan's true motives and the effect SDI would have on the nuclear arms race. Within the government, SDI created waves as well. Those in the defense establishment, such as Secretary of Defense Caspar Weinberger, were eager to throw out the old nuclear strategic doctrine that had limited the United States for much of the Cold War, and many in the military believed that recent technological advances would help the next BMD effort overcome the hurdles that had plagued earlier systems. Meanwhile, those tasked with diplomatic duties, such as Secretary of State George Shultz, were less confident in the emerging technology and saw SDI as an unnecessary cause of tension in U.S. foreign relations, favoring instead a more pragmatic approach to international affairs.

Supporters of SDI saw it as a bold chance to step away from reliance on the concept of mutual assured destruction (MAD), believing that a missile shield would allow the United States to pursue its foreign policy goals (opening markets, encouraging democratization, ensuring regional stability) without fearing reprisals from its rival for global influence. Some historians have linked this optimistic faith in American know-how with larger theories on Reagan's inner workings, leading many to associate him more closely with "Star Wars" than any other president has been linked to a BMD system developed under his watch.

Critics charged that SDI, like previous BMD programs, jeopardized the security that the Cold War superpowers had created with the ABM Treaty and encouraged the militarization and weaponization of space. Planners based "Star Wars," they said, on untested and infeasible technologies and did not design the defense to protect against cruise missiles, airplanes, or other methods of warhead delivery. Some historians contend that links between SDI and Reagan's psyche were a detriment to the program, suggesting that the one-time actor's fondness for movies inspired him to incorporate unrealistic aspects of decades-old films referencing missile shields and futuristic defenses into his vision for SDI.

By 1985, the congressional Office of Technology Assessment released a report concluding that the survival of the U.S. population in case of a nuclear attack was not a realistic goal for SDI. The report also claimed that deployment of a BMD system would create more problems for the nation's security and adversely affect arms control negotiations. Supporters, however, argued that SDI was important to national security even if technologically imperfect—many claimed that the program would be a powerful negotiating chip in dealings with the Soviet Union, which under Mikhail Gorbachev was becoming increasingly open to nuclear reductions.

Further congressional reports and independent studies assailed SDI's chances for success, and with Reagan at the end of his second and last term, support and funding for the ambitious plan lost momentum. By the 1991 collapse of the Soviet Union, President Bush had refocused SDI from its emphasis on countering a massive Soviet attack to a system known as Global Protection Against Limited Strikes (GPALS). GPALS looked at smaller-scale options to defend against less cataclysmic scenarios (*see* Global Protection Against Limited Strikes).

Technical Details

From its start, the SDI program considered a variety of options for shooting down incoming warheads. Previous U.S. missile defense proposals sought to explode antimissile missiles, often equipped with nuclear warheads of their own, in the vicinity of the offensive missiles high above the surface, thereby preventing enemy warheads from reaching targets in the United States. Some elements of SDI considered this strategy, but others looked at different options and components not seriously considered by designers of prior systems. These new ideas included space-based radars, lasers, and particle beams. Many of these ideas proved ineffectual and did not survive budget cuts and reorganized incarnations of BMD strategies.

Unlike previous BMD programs such as Sentinel and Safeguard, SDI was not a single-strategy defense relying on only one method of intercept. Instead, Reagan had created SDI to study a variety of antimissile options. The program conducted research into detection areas, such as space- and ground-based sensors, and intercept methods, such as directed-energy weapons and the kinetic "hit-to-kill" strategies that survive to this day in current BMD programs. Nearly all current U.S. BMD programs, from the Patriot theater missile defense to the Airborne Laser, owe some of their inspiration to ideas nurtured under SDI.

Kinetic-energy elements of SDI included the Homing Overlay Experiment (HOE), the Exoatmospheric Reentry-Vehicle Interception System (ERIS), and the Extended Ranger Interceptor (ERINT). HOE was a series of four missile tests conducted in 1983 and 1984 at the Kwajalein Missile Range in the Marshall Islands. The goal of the tests was to intercept and destroy an ICBM in space using nonnuclear means, in this case slamming the interceptor into the incoming warhead. For each test, a Minuteman missile launched from Vandenberg Air Force Base in California served as the target. About twenty minutes later, an interceptor missile, also a converted Minuteman, was launched from Kwajalein. While in space, infrared homing equipment guided the interceptor. The interceptor carried a "kinetic kill device" consisting of a set of aluminum vanes that unfurled before impact. The first three attempts failed to achieve a successful intercept owing to a variety of mechanical and software problems, but on June 10, 1984, the fourth HOE test resulted in a successful intercept. The ERINT program, designed to demonstrate the guidance accuracy of a small, radar-homing kill vehicle, led designers to choose the interceptor as the basis for the Patriot Advanced Capability 3 (PAC-3) missile now in use.

Directed-energy weapon systems tested or explored under SDI included the Airborne Laser Laboratory, the neutral particle beam, the charged particle beam, and an X-ray laser. More than any other aspect of SDI, these elements inspired the "Star Wars" moniker taken up by supporters and critics. Directed-energy beams—once the realm of science fiction—marked a significant departure from previous missile defense designs, which had relied on nuclear detonations or kinetic interceptors that could "hit a bullet with a bullet." The Airborne Laser Lab was a gas-dynamic laser mounted in a commercial Boeing 707. During the eleven-year experiment, the laser system destroyed five AIM-9 Sidewinder air-to-air missiles and a Navy BQM-34A target drone, but it did not show much promise as a deployable weapon effective against real-world threats. However, the basic design of this system, mounting a laser on an aircraft, is the inspiration behind a current airborne laser project.

SDI-sponsored sensor systems included the Boost Surveillance and Tracking System (BSTS), the Space Surveillance and Tracking System, and the Space-Based Radar. BSTS proved too large and costly to field but served as an initial model for smaller, cheaper sensors that would become a part of later proposals to create a constellation of orbital platforms.

In its later years, with direction from President George H. W. Bush to focus on a less ambitious missile shield, SDI found hope in the Brilliant Pebbles system. With Brilliant Pebbles, some 4,600 small interceptors were to deploy in orbit, each capable of homing in on and destroying incoming warheads, and each "pebble" independent from any other guidance or control system. Critics predicted, however, that many nations would object to placing so many weapons in orbit, not to mention the strain on satellite tracking systems from the large number of pebbles.

Others also sought to refocus SDI's attention away from broader missile defense goals to more specific, smaller-scale defenses that, while protecting the United States from attack, relied more on technologies that showed promise and did less to aggravate international security. Some suggested that a more effective defensive deployment might be possible within the terms of the ABM Treaty with a limited system designed to protect against accidental and unauthorized launches. Although this Accidental Launch Protection System (ALPS), with its ABM Treaty–authorized 100 interceptors at one site, could not defend the United States against missiles launched from submarines or against missiles armed with large numbers of decoys and countermeasures, much less a large-scale attack, it did serve as a bridge between the ambitious program identified with Reagan to the more modest BMD testing of the 1990s.

—John Spykerman

See also: Brilliant Eyes; Countermeasures; Department of Defense; Missile Defense; Strategic Defenses; Theater Missile Defense; X-Ray Laser

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STRATEGIC DEFENSES

Strategic defenses are those systems a country employs to protect its territory and population from adversary attack against the homeland. Typically such defenses have included navies, coast guards, air defenses, and antiballistic missile interceptors.

History and Background

Soon after the first German V-2 rockets struck Britain during World War II, U.S. military planners began dreaming of a defense to counter ballistic missile attacks. Debates over the costs and benefits of a workable defense against long-range (strategic) missile defenses have been fierce—supporters and opponents have returned over the decades to contest each other on the financial costs, technological feasibility, and political ramifications of constructing such a shield. Prior to President Ronald Reagan's ambitious Strategic Defense Initiative (SDI), which explored several ballistic missile defense (BMD) concepts in the 1980s, the United States attempted to field a series of nuclear-armed interceptor systems. Defense officials eventually canceled each of these programs when it became evident that either the technical merits of the programs were weak or the political and economic costs were too high. Changes in administration, too, have had an effect on various BMD programs, with presidents alternately increasing and decreasing funding for BMD while also refocusing particular systems from narrower to broader missions and back again.

Early U.S. Missile Defense Programs

In 1957, the United States began work on its first ballistic missile defense, the Nike-Zeus system. After about five years, it became apparent to the program's evaluators that the Nike-Zeus missile would not provide an effective defense against a Soviet attack. In 1962, the United States switched to a modified version of the Nike-Zeus program, the Nike-X, which used two kinds of nuclear-tipped interceptors and new "phased-array" radars. Under President Lyndon B. Johnson, Nike-X became the Sentinel system, and Johnson announced that the revamped effort would focus more on defending against a smaller Chinese nuclear threat than on attempting to thwart a massive attack from the Soviet Union. China had recently developed nuclear weapons technology and had the capacity to produce only a few long-range offensive missiles. Thinking that this was more feasible than attempting to stop hundreds or thousands of Soviet warheads, Johnson switched Sentinel's mission to the Chinese threat (*see* Nike Zeus; Sentinel).

The Nike-X/Sentinel system consisted of two missiles. Spartan, a long-range missile, was designed to intercept warheads outside of the Earth's atmosphere. The first test of this 460-mile-range missile occurred in March 1968. The Spartan was to carry a 5-megaton warhead designed to kill enemy warheads not by blast but by an X-ray radiation flux. During an August 1970 test, Sentinel intercepted a Minuteman reentry vehicle for the first time. In January 1971, a Spartan missile intercepted a Polaris submarine-launched ballistic missile that had deployed decoys and penetration aids in an attempt to overwhelm the Spartan radar systems. These tests, however, were performed under controlled conditions that did not simulate realistic attack scenarios (*see* Minuteman ICBMs; Penetration Aids; Spartan).

The Sprint missile was the other component of the Sentinel/Safeguard system. Sprint was to serve as a last-ditch defense inside the Earth's atmosphere if and when the longer-range Spartan missiles failed to destroy their targets. In November 1965, the first Sprint missile underwent testing after extensive studies showed that a high-speed, 25-mile-range interceptor was possible. The cone-shaped Sprint was powered by a two-stage, solid-propellant rocket motor. The missile reached speeds in excess of Mach 10 that caused extreme thermodynamic heating and demanded sophisticated shielding. Special command links hardened and protected against nuclear electromagnetic pulses guided the Sprint, which was equipped with a 1-kiloton enhanced radiation warhead that could destroy the enemy reentry vehicle with a very high neutron flux. Designers intended the flight time for a Sprint intercept to be less than fifteen seconds. Testing continued on both systems until 1973. Sprint missiles were eventually incorporated into the Safeguard system (*see* Safeguard Antiballistic Missile [ABM] System; Sprint).

Safeguard was a U.S. BMD system briefly deployed in 1975. In 1969, President Richard M. Nixon announced plans for the system, basing Safeguard on earlier proposals such as the Sentinel and Nike-Zeus programs. However, Nixon, like Johnson, changed the planned missile shield's mission—this time from protecting the general public in case of a Chinese nuclear attack to providing protection for a few crucial military sites to improve the survivability of U.S. land-based deterrent forces. Safeguard consisted of detection radar and long- and short-range ABM missiles equipped with nuclear warheads designed to intercept incoming missiles or fractional orbital bombardment systems (FOBS).

Safeguard became operational on October 1, 1975, but one day later, the U.S. House of Representatives voted to shut down the program. Opponents of the system argued that the development of Soviet multiple independently targetable reentry vehicles (MIRVs) meant that Safeguard could not handle a concerted Soviet attack. In addition, several other technical problems reduced its effectiveness, such as the predicted failure of tracking radars after the interceptor detonated its nuclear warhead.

Political issues, both domestic and international, played heavily in the Safeguard debate. The U.S. Senate passed Phase I of the program on a 50–50 vote, with Vice President Spiro T. Agnew casting the tie-breaking ballot. On top of its defensive value, supporters maintained Safeguard would create a bargaining chip in upcoming arms control talks with the Soviet Union. Safeguard designers originally intended the system to protect up to twelve sites, but during negotiations with the Soviet Union on the Anti-Ballistic Missile (ABM) Treaty, negotiators reduced the number of sites to two: Grand Forks Air Force Base in North Dakota, and Washington, D.C. Following an amendment to the treaty in 1974 limiting each side to just one ABM site, Grand Forks, home to 150 Minuteman intercontinental ballistic missiles, emerged as the sole location of a U.S. ballistic missile defense system.

With Safeguard's detection equipment working with a nearby radar installation, the system could detect Soviet ICBMs as they passed over the North Pole, giving operators just a few minutes to plan their reaction. The U.S. response consisted of two types of missiles: the long-range Spartan and the short-range Sprint, both armed with nuclear warheads. Designers created Safeguard to provide a layered defense: The Spartan ABMs would first attack incoming clusters of warheads, booster rockets, and decoys, and Sprint ABMs would intercept survivors.

Opponents, however, argued that with only 100 interceptors stationed in North Dakota, the Soviet Union could easily overpower the defense. Congressional faith in the project began to diminish. The Senate initially resisted efforts to terminate the program, but following revelations that the Pentagon had come to the same conclusions on Safeguard's ineffectiveness a year earlier, senators agreed to end operational funding. The U.S. Army then began dismantling Safeguard, finishing the task in February 1976. The total program cost had amounted to $5 billion (some $25 billion in 2004 dollars).

U.S. BMD programs have since abandoned Safeguard's method of using nuclear weapons to destroy incoming missiles. For moral and technical reasons, the United States now pursues other BMD options, including hit-to-kill kinetic-energy devices and directed-energy lasers. These ideas surfaced in the Strategic Defense Initiative of the 1980s and survive in systems conceived since the 1990s.

Soviet Missile Defenses

The Soviet Union also has explored strategic missile defense. Although the Soviets, and later the Russians, did not subject their BMD programs to the public scrutiny that U.S. programs have endured, many believe these systems have encountered similar technological and economic barriers to effectiveness over the years. The Soviet Union designed its first system in the early 1960s to protect Moscow. Originally the Soviets intended to have eight BMD complexes in the Moscow region, but construction slowed, and by 1970 they had built only four of the sites, with a total of sixty-four interceptors. Plans for additional sites were scaled back in 1972, when the signing of the ABM Treaty limited the number of sites and interceptors (*see* Moscow Anti-Ballistic Missile System).

The Moscow system relied on one large radar for long-range tracking and battle management, with a network of smaller radars on the periphery of the Soviet Union's territory to provide early warning information. Like U.S. systems, the Soviet system used a nuclear-armed missile (called the "Galosh") as its interceptor. The initial Soviet system deployed around Moscow is known as the S-300, with S-400 and S-500 upgraded versions surfacing in later years. The Soviet Union and Russia have sold S-300 interceptors to a handful of countries, including China. Several problems exist with this system. First, its radars are vulnerable to "blackout," or blinding by nuclear blasts, during a defense of an attack, including by those blasts from its own interceptor missiles. The system also could not detect missiles approaching from certain directions. And like most U.S. systems, Soviet defenses could not overcome countermeasures, such as decoys and chaff, or massive attacks involving hundreds or thousands of warheads (*see* Countermeasures).

The Soviet Union upgraded its system in the late 1970s, installing a two-layer defense using two types of nuclear-armed interceptors. The updated system, still nominally in operation, relies on phased-array radars for coverage. The system is still intended to defend only Moscow and is not a comprehensive national missile defense. The Department of Defense estimates that the Soviet/Russian system is no more advanced than the old Safeguard defense, but despite its problems, the system runs at partial capability with an unclear state of readiness.

—John Spykerman

See also: Missile Defense; Strategic Defense Initiative

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STRATEGIC FORCES

Strategic forces are weapons and delivery systems that are intended to deter an armed conflict or destroy an enemy's military. The term "strategic forces" generally refers to nuclear weapons and the systems that deliver them to their targets. There are currently nine nations that possess nuclear forces: the United States, the United Kingdom, Russia, France, the People's Republic of China, India, Pakistan, Israel, and (presumably) North Korea (the Democratic People's Republic of Korea, DPRK). The nature of their strategic forces is influenced by their technical and economic resources, strategic doctrines and culture, and the political and military threats they face. Because of the sunk costs involved in developing strategic forces, systems often remain in arsenals decades after their initial deployment (*see* Ballistic Missiles; Intercontinental Ballistic Missiles; Medium-Range Ballistic Missiles; Submarines, Nuclear-Powered Ballistic Missile; Sea-Launched Cruise Missiles; Submarine-Launched Ballistic Missiles).

U.S. Strategic Forces

The U.S. Strategic Command (STRATCOM), headquartered at Offutt Air Force Base in Nebraska, commands the strategic forces of the United States. The Nuclear Posture Review (NPR) submitted by the Department of Defense to Congress in December 2001 set forth the number of U.S. nuclear forces and their dispositions. As of January 2004, the United States maintained a total force of 1,227 strategic nuclear delivery vehicles and 5,968 strategic nuclear warheads. These forces are split into a "Triad" of intercontinental ballistic missiles (ICBMs), bombers, and submarine-launched ballistic missiles (SLBMs).

Also as of 2004, the United States maintains a force of 550 ICBMs and 1,700 ICBM warheads. Fifty of the ICBMs are MX/Peacekeepers, which have a range of roughly 7,000 miles and can carry up to ten Mk-21 reentry vehicles, each of which houses a 300-kiloton W-87 warhead. The remaining 500 U.S. ICBMs are Minuteman III missiles, which have a range of more than 7,000 miles and can carry either three W-78 or W-62 warheads. Under the 1993 Strategic Arms Reduction Treaty (START II), the current three-warhead loading was to be changed to a single W-87/Mk-21 by 2007. Though START II was never ratified, the United States still plans to abide by this treaty provision and download its ICBM force. The Minuteman III missile force continues to be modernized under a $6 billion, six-part plan to improve the weapon's accuracy and reliability and to extend its service life to approximately 2020 (*see* Minuteman ICBMs).

The United States maintains two types of long-range bombers for nuclear missions: the B-2A Spirit and the B-52H Stratofortress. Neither is maintained on a day-to-day alert, and both also conduct conventional missions, as was seen in the 2003 war in Iraq (*see* Bombers, U.S. Nuclear-Capable; Stealth Bomber [B-2 Spirit]).

The B-52 can deliver cruise missiles, gravity bombs, or a combination of both. The United States currently maintains a force of 142 operationally deployed B-52s in its arsenal. The bomber is expected to stay in operation until 2040. The B-52, called by the U.S. Air Force the "workhorse of nuclear weapons employment," is the only carrier of nuclear cruise missiles. Each B-52 can carry up to twenty air-launched cruise missiles (ALCMs) or advanced cruise missiles (ACMs), with up to eight missiles carried internally and up to twelve carried externally.

The U.S. force of twenty B-2 bombers is scheduled for replacement around 2040; a follow-on bomber program began in 1998. The nuclear weapons that are carried by the B-2 include the B61-7, B61-11, and B83 gravity bombs. Each B-2 can be armed with either B61 or B83 bombs, but the two cannot be mixed in a single payload. The B-2, the only carrier of the B61-11 earth-penetrating nuclear bomb, is currently undergoing a $600 million modernization program.

Only recently was it revealed that a third strategic bomber, the B-1B, had been maintained as nuclear capable. In the past, the U.S. Air Force had described it as "conventional only." The 1994 NPR ordered an end to the B-1B's nuclear capability (which occurred officially on October 1, 1997). Of the original 100 B-1Bs, 92 remain. The Air Force will reduce that number to 66 by October 2004 (*see* United States Air Force).

As of mid-2003, there were sixteen operational Ohio-class nuclear-powered ballistic missile submarines (SSBNs, for "ship submersible ballistic nuclear"), two fewer than a year earlier. The Ohios carry 384 Trident SLBMs (24 on each boat) and as many as 2,880 warheads—about half the operational warheads in the strategic arsenal. There are two types of Trident missiles: the Trident I C4 and the newer, more accurate, and longer-range Trident II D5. Twelve submarines have been upgraded to carry D5s, eight in the Atlantic and four in the Pacific. After the remaining Pacific-based subs are retrofitted to carry D5s, the D5 will arm all U.S. SSBNs. The SLBMs carry two types of reentry vehicles (RVs) and warheads: the Mk-4 with the W-76 warhead and the Mk-5 with the W-88 warhead. The Mk-4/W-76 combination is the more common, with almost 2,500 warheads deployed on fourteen submarines. The Mk-5 carries the W-88, the most powerful missile warhead in the U.S. arsenal. Production of the W-88 ended in 1989.

The four oldest Trident SSBNs (Ohio, Michigan, Florida, and Georgia) are being converted into cruise missile submarines under a $3.8 billion program. Of the twenty-four launch tubes on each sub, twenty-two will be fitted with canisters that hold seven Tomahawk cruise missiles, for a total of 154 per boat. The two remaining launch tubes will house pressurized chambers for Special Operations

Forces. The first cruise missile submarine (Ohio) is scheduled to be delivered in late 2006, with an initial operational capability in 2007. All four types should be operational in 2008.

With an improvement in targeting delivery, and effects-based technologies, the United States has also begun to deploy a nonnuclear strategic capability. Previously, nuclear weapons were considered the only viable strategic combat option because conventional weapons were not highly accurate, and nuclear weapons had a large enough blast to be able to ensure destruction of a target even if the weapon was not deployed accurately. The nature of combat is changing, however, and modern militaries are developing the ability to target and destroy targets with an increasing degree of accuracy and destructiveness. These weapons can be directed at hardened targets or command, control, and communications units with a degree of accuracy that reduces the need for nuclear weapons.

The Joint Direct Attack Munition (JDAM), the Joint Standoff Weapon (JSOW), and the longer-range Joint Air-to-Surface Standoff Weapon are all examples of nonnuclear strategic weapons. Some believe that these weapons can be delivered with a degree of accuracy and focused destruction that can essentially replace the need for nuclear strategic arms in combat (*see* United States Nuclear Forces and Doctrine).

British Strategic Forces

The United Kingdom seeks to retain a credible minimum nuclear deterrent based on its Trident submarine force. Britain's Trident force provides an operationally independent strategic nuclear capability in support of the North Atlantic Treaty Organization (NATO) and its strategy of war prevention. British strategic forces serve as the ultimate guarantor of British national security. Britain operates four Vanguard-class SSBNs (for "ship submersible ballistic nuclear") carrying a total of sixty-four Trident II D5 SLBMs, each capable of carrying three warheads (*see* British Nuclear Forces and Doctrine).

Russian Strategic Forces

Russia maintains a large nuclear force with more than 1,000 strategic delivery systems and more than 5,000 strategic nuclear warheads. Russia's strategic forces, much like those of the United States, are divided into a Triad of bombers, SSBNs, and ICBMs.

Russia's seventy-eight strategic bombers are part of the Russian Air Force's 37th Air Army. Its current strategic bomber force consists of three types: Bear H6, Bear H16, and Blackjack. Russia's thirty-two Bear H6 bombers, also known by the designation Tu-95MS6, can carry six AS-15A air-launched cruise missiles or six bombs. Its thirty-one Bear H16 bombers, also known by the designation Tu-95MS16, can carry sixteen ALCMs or bombs.

Economic constraints, a shrinking SSBN fleet, and obvious safety concerns in the aftermath of the tragedy on board the Russian submarine *Kursk,* which sank with the loss of all hands in August 2000, have led to substantial decreases in the number of SSBN patrols and general-purpose submarine (SSN/SSGN) patrols. According to the U.S. Navy, in 1991 there were thirty-seven SSBN patrols. In 2001, there was one. Some Soviet SSBNs, however, are able to launch their SLBMs while in port.

Only fourteen of Russia's SSBNs are considered to be operational: six Delta IIIs, six Delta IVs, and two Typhoons. Within these platforms, Russia deploys three types of SLBMs: ninety-six Stingrays, forty Sturgeons, and ninety-six Skiffs, all of which are MIRVed (that is, equipped with multiple independently targetable reentry vehicles) and carry a total of 1,072 nuclear warheads with a total blast potential of 262 megatons.

Russia's primary deterrent force is made up of some 706 ICBMs, which carry 3,011 warheads with a total blast potential of 1,656 megatons. This force is divided into five types of missiles: 144 Satans, 137 Stilettos, 36 Scalpels, 360 Sickles, and 29 SS-27s. Satan missiles, also known as the SS-18, are a silo-based ICBM with a range of up to 9,000 miles, depending on the load being carried. The warheads have an estimated yield of up to 750 kilotons. Stiletto missiles, also known as the SS-19, are silo-based ICBMs. Some SS-19s are being deactivated to make room for SS-27s, which can use the same silo as the SS-19. Scalpel missiles, also known as the SS-24, can be either silo- or rail-based. The silos for all Scalpels have been dismantled, and all that remain are rail-based versions. Sickle missiles, also known as the SS-25 and as Topol, are road-mobile, single-warhead missile systems that are being replaced by the SS-27. SS-27 missiles are also road-mobile, single-warhead missile systems and have a range of 10,000 kilometers (*see* Bombers, Russian and Chinese Nuclear-Capable; Russian Nuclear Forces and Doctrine).

French Strategic Forces

France continues to maintain its own strategic nuclear capability, which is divided between SSBNs and aircraft. It retired its land-based intermediate-range missile force in the 1990s.

France's primary nuclear force today resides in its SSBN fleet. France maintains four SSBNs of three classes: two of the new Triomphant class, one of the L'Inflexible class, and one of the Redoubtable class. The two Triomphant SSBNs each carry sixteen M45 SLBMs with six of the new TN-75 warheads.

France maintains forty-five Mirage 2000N bombers based at Luxeuil and Istres. The bomber has a range of 2,750 kilometers and can carry a single TN-81 warhead with an estimated yield of 300 kilotons. The Mirage will eventually be replaced by the Rafale, France's multipurpose navy and air force fighter-bomber for the twenty-first century. Its roles include conventional ground attack, air defense, air superiority, and nuclear delivery of the ASMP (Air Sol nucléaire Moyenne Portée) and/or ASMP-A (Air Sol nucléaire Moyenne Portée–Amélioré) short-range attack missiles. The navy version (Rafale M) entered the inventory in 2001 to form Squadron 12F at Landivisiau and will replace the Super Étendard as France's carrier-based aircraft. The air force's Rafale D will attain a nuclear-strike role in about 2005. The air force still plans to buy a total of 234 Rafales (*see* French Nuclear Forces and Doctrine).

Chinese Strategic Forces

China currently has close to 250 strategic weapons structured in a Triad of land-based missiles, bombers, and SLBMs. The emphasis of China's arsenal is primarily on the land-based missile leg of the Triad.

The missile leg consists of a variety of weapons. In all, China has between twenty and thirty ICBMs, fifty to a hundred intermediate-range ballistic missiles (IRBMs), twenty-five to fifty medium-range ballistic missiles (MRBMs), and many short-range ballistic missiles. These are designated by the United States as CSS-2, -3, -4, -5, and -6.

The Chinese already have road-mobile ballistic missiles in service, although they are currently only IRBMs and MRBMs. This mobile missile force is limited in number, accuracy, and throw weight. The missiles are not yet capable of accommodating MIRV technology, nor are they supported by Global Positioning System guidance systems.

The Hong-6, a modified version of the Soviet Badger, is the only active in-service Chinese bomber capable of carrying nuclear bombs. Its operational effectiveness is limited by its short range, its slow speed, and its obsolete technology.

China's submarines are regarded as barely operational. China has stated that it has built two Xia-class SSBNs, each of which can carry twelve SLBMs. The Xia is a modification of the Han-class nuclear-powered attack submarine, lengthened to house twelve missile tubes. Reports conflict, however, about whether China has actually deployed two SSBNs. Most analysts estimate that only one is operational, and that it has only operated for short periods in China's coastal waters (*see* Bombers, Russian and Chinese Nuclear-Capable; Chinese Nuclear Forces and Doctrine).

Indian Strategic Forces

India has developed a strategic dyad relying on aircraft and missiles to deliver its estimated stockpile of sixty to ninety strategic nuclear warheads.

The country has several types of aircraft that could be used to deliver a nuclear weapon. Considerations of range, payload, and speed, however, narrow the choices to one or two types. The Indian aircraft most likely to be used for this purpose are the MiG-27 and the Jaguar. India's 165 MiG-27 Floggers are nuclear-capable Soviet aircraft with a range of approximately 800 kilometers. India designates the MiG-27 the Bahadhur, which means "valiant" or "brave." India's 131 Jaguar IS/IBs, known as the Shamsher (for "sword"), have a range of 1,600 kilometers.

India deploys one ballistic missile, the 150 km range *Prithvi I.* A single-stage, dual-engine, liquid-fueled, road-mobile, short-range ballistic missile (SRBM), the *Prithvi II,* has a range of 250 kilometers. The two-stage Agni (fire) IRBM is also under development and has been tested to a range of 1,500 kilometers, but its status remains unclear. An improved version with a longer range (over 2,000 kilometers) is under development. In test launches, the missile designated *Agni II* flew 2,200 kilometers and, according to Indian officials, landed fewer than 100 meters from its intended target. Both road- and rail-mobile versions of the *Agni II* are under development. The development of a longer-range *Agni III* with a range of up to 3,500 kilometers has not been confirmed. Rumors persist concerning Indian plans for an ICBM program referred to as the Surya. Most components needed for an ICBM are available from India's indigenous space program.

In addition to air- and land-based nuclear-capable forces, India is working on at least two naval systems that may be equipped to carry nuclear warheads in the future. The submarine-launched Sagarika (oceanic) SLBM is in advanced development. U.S. intelligence believes it is an SLBM and estimates that it will not be deployed until 2010 or later. Another potential candidate is the Dhanush (bow) sea-launched ballistic missile, which has a range of 250 kilometers. Neither the Dhanush nor the Sagarika has been declared nuclear-capable by Indian authorities (*see* Indian Nuclear Weapons Program).

Pakistan's Strategic Forces

Experts estimate that Pakistan's nuclear arsenal consists of somewhere between twenty-four and forty-eight strategic nuclear warheads.

The aircraft in the Pakistani Air Force that is most likely to be used in the nuclear weapon delivery role is the F-16, built by the United States. These aircraft have a range of 1,600 kilometers, and Pakistan owns forty-four of them.

Pakistan also maintains two types of nuclear-capable missiles, the Ghauri I and the Ghauri II. The Ghauri I is basically the North Korean Nodong missile, with a range of 1,500 kilometers. The Ghauri II has a range of 2,300 kilometers. A third version of the Ghauri, with an unconfirmed range of 2,500 to 3,000 kilometers, is under development and was test-launched on August 15, 2000 (*see* Pakistani Nuclear Weapons Program).

Israeli Strategic Forces

Israel neither acknowledges nor denies that it has nuclear weapons, although the rest of the world regards Israel as a de facto nuclear weapons state. It has been estimated that Israel could have as many as 200 strategic nuclear warheads in forms as varied as land mines, artillery, and high-yield thermonuclear weapons.

Israel currently deploys two nuclear-capable ballistic missile types. The Jericho I has a range of 660 kilometers, and the Jericho II has a range of 1,500 kilometers. Additionally, the Shavit space-launch vehicle, with an intercontinental range of 7,800 kilometers, could be modified to carry nuclear weapons.

In terms of nuclear-capable aircraft, Israel could choose between two types purchased from the United States: the F-4E-2000 Phantom or the more modern F-16 Falcon (*see* Israeli Nuclear Weapons Program).

North Korean Strategic Forces

North Korea, officially known as the Democratic People's Republic of Korea, possesses two missiles capable of delivering strategic nuclear weapons. The Nodong is a modified Scud-C missile with a range of 1,300 kilometers. The Taepo Dong-2 (TD-2) is said to be a two- or three-stage missile with a range estimated between 3,650 and 4,300 kilometers. The size of the North Korean nuclear force is currently a matter of much debate within intelligence communities, but there is a general presumption that North Korea has defied international inspections and constraints long enough to have developed the fissile material necessary to produce at least a few rudimentary nuclear devices (*see* North Korean Nuclear Weapons Program).

—*Abe Denmark*

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STRATEGIC OFFENSIVE REDUCTIONS TREATY (SORT)

The latest in a series of offensive strategic nuclear weapons treaties between the United States and the Soviet Union, the Strategic Offensive Reductions Treaty (SORT) is also known as the Moscow Treaty. Signed in Moscow on May 24, 2002, it is only two pages in length, the shortest bilateral arms control treaty ever signed. Its brevity is meant to reflect the changed relationship between the two countries, which are now strategic partners rather than adversaries, a major change since the Cold War. Presidents George W. Bush and Vladimir Putin agreed on the principal elements of the treaty at the Crawford, Texas, summit in November 2001. The treaty commits both parties to continued reductions in their strategic nuclear arsenals, with a target of 1,700 to 2,200 deployed strategic warheads by 2012. There are no provisions for verification, inspections, or compliance, nor does the treaty require the parties to destroy the warheads they remove from deployed status. In fact, the United States plans to keep some intact warheads in a "hedge" that it can reconstitute quickly in an emergency. This treaty essentially took the place of a third Strategic Arms Reduction Treaty (START III).

—Jeffrey A. Larsen

See also: Arms Control; Hedge; Nuclear Posture Review

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STRATEGIC ROCKET FORCES

The Strategic Rocket Forces (SRF), created in 1959, was a separate, elite branch of the Soviet armed forces during the Cold War. It was responsible for the operation of the bulk of the Soviet Union's strategic nuclear arsenal. With the fall of the Soviet Union in 1991 and Soviet/Russian participation in various missile treaties limiting the size of the superpower missile arsenals (including the Intermediate-Range Nuclear Forces [INF] Treaty of 1987, the two Strategic Arms Reduction Treaties [START I and START II] of 1991 and 1993, and the Moscow Treaty, or Strategic Offensive Reductions Treaty [SORT] of 2002), the SRF has waned somewhat in importance. In 1997, it merged with Air Defense Forces and the Missile-Space Defense Troops (responsible for early warning radar and space tracking) to cut costs. The shrinking budget, overall decline of the Russian military, and continuing friendly relations with the United States have probably doomed the SRF as an independent force. In August 2000, the Russian Security Council decided to relegate the SRF to a separate command under the air force and moved to eliminate its independent status by 2006. Its aging force of intercontinental ballistic missiles (ICBMs) will be reduced based upon the service life of each individual missile. Finally, the Missile-Space Defense troops were taken away and merged with the air force.

The current SRF force is divided into nineteen missile divisions operating a mix of silo, rail, and mobile missiles. Although the majority of Russian ICBMs are old, the Russians introduced the SS-27 Topol in 1997. The SS-27 is both silo and land-mobile based. Units suffer from a severe lack of spare parts, lubricants, and fuel to operate their mobile launch vehicles. In some instances, officers have used their own money to purchase necessary parts for their missiles to remain on alert. Although traditionally the SRF enjoyed the greatest percentage of highly educated officers, recruitment of junior officers has recently become a problem. The Soviet-era draft system remains in effect, and draft dodging is a serious problem. Thus, many unqualified personnel are forced to serve in positions they would not normally occupy. Even feeding the troops has become a problem. The SRF has been forced to grow its own food to feed its troops. These "SRF farms" account for over 40 percent of its food needs.

—Zach Becker

See also: Russian Nuclear Forces and Doctrine

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SUBMARINES, NUCLEAR-POWERED BALLISTIC MISSILE (SSBNS)

Nuclear-powered ballistic missile submarines are traditionally referred to as SSBNs (for "ship submersible ballistic nuclear"); they carry and launch submarine-launched ballistic missiles (SLBMs). Five nations have SSBNs: the United States, the Russian Federation, the United Kingdom, France, and China (*see* Strategic Forces; Submarine-Launched Ballistic Missiles).

U.S. SSBNs

For the United States, the original SSBN submarine force consisted of forty-one Polaris submarines, with the first, the USS *George Washington* (SSBN 598),

HMS Vanguard, *the Royal Navy's first Trident nuclear submarine, sails up the Clyde River to the British navy Clyde Submarine Base at Faslane. (Robin Adshead/The Military Picture Library/Corbis)*

commissioned on December 30, 1959. It was deployed on the first ever fleet ballistic missile (FBM) patrol with a full load of sixteen Polaris missiles in November 1960. The first ten FBM submarines (598 and 608 classes) carried the various generations of the Polaris missile (A1, A2, and A3). The George Washington class (SSBN 598) and Ethan Allen class (SSBN 608) deployed with Polaris A1s. These Polaris submarines were 380 feet long with a 33-foot beam (width) and weighed 6,700 tons. The Lafayette class (616), consisting of nine boats, deployed with Polaris A2s and was later converted to accommodate the Poseidon C3 missile. These Poseidon submarines were 425 feet long with a 33-foot beam and weighed 8,250 tons. These submarines also carried sixteen missiles. The next thirty-one FBM submarines were constructed initially for Polaris but were later converted to the Poseidon C3 missile. The Poseidon missile was first deployed on the USS *James Madison* (SSBN 627) on March 31, 1971.

The Trident (Ohio 726 class) submarine, the largest of the U.S. Navy, has a length of 560 feet with a beam of 42 feet and weighs 18,700 pounds. It can carry twenty-four ballistic missiles with multiple independently targetable reentry vehicle (MIRV) warheads that can be accurately delivered to selected targets from almost anywhere in the world's oceans. The Trident submarine is designed to carry two types of SLBMs, the Trident C4 or D5 (*see* United States Navy; United States Nuclear Forces and Doctrine).

British SSBNs

The original UK SSBN program was supported by the United States under the 1963 Polaris Sales Agreement. The UK developed its own SSBN program, however. The British first produced the Resolution-class submarine, which was similar to the U.S. Los Angeles–class attack submarine. It was basically a modification of the Valiant-class fleet submarine, another attack submarine, but enlarged to incorporate the missile compartment between the fin and the nuclear reactor. The four Resolution-class submarines were built with a length of approximately 400 feet and weighed 8,500 tons. Each Resolution-class submarine could carry sixteen Polaris A3 missiles. When the United States replaced Polaris with Poseidon, the UK decided to upgrade its existing Polaris system with a new warhead, code-named Chevaline. In 1982, the UK began replacing Polaris with Trident. In 1993, after the completion of the first new Vanguard-class (Trident) SSBN, it began replacing the Resolution-class SSBNs. After twenty-eight years of service, the last Resolution-class SSBN was decommissioned in August 1996.

There are currently four Vanguard-class (Trident) SSBNs (Vanguard, Victorious, Vigilant, and Vengeance). The Vengeance entered service in February 2001. The Vanguard, weighing 15,900 tons, over 490 feet long, and with a beam of 42 feet, has the capacity to carry sixteen Trident II D5 missiles (designated UGM-133A), each capable of carrying up to twelve MIRVs. Plans were announced in 1993 to limit the number of warheads carried to a maximum of ninety-six per submarine; this has been further limited to forty-eight (*see* British Nuclear Forces and Doctrine).

Russian SSBNs

The Russian Federation inherited an aging SSBN fleet from the former Soviet Union with five classes of SLBMs. The first purpose-built Soviet SSBN was the Golf class (Project 628) submarine, deployed in the late 1960s, which carried three SS-N-4 SLBMs. It could fire these missiles, however, only while surfaced. Later, a modified version, the Golf II class, could launch the newer SS-N-5 SLBM submerged. Both boats, however, were diesel powered. The first nuclear-powered Soviet SSBN was the Hotel I class (Project 658). Like Golf I, it carried three surface-launched SS-N-4 SLBMs. The Golf II class (Project 658M) subs were essentially converted Hotel I–class submarines that carried three SS-N-5 SLBMs. The Yankee-class (Project 667A) SLBM, the first SLBM designed for surface-launched missiles, followed in the 1970s. It carried sixteen SS-N-6 SLBMs. The Delta I– and Delta II–class subs (Project 667B and Project 667BD) were essentially Yankee-class SSBNs but with twelve SS-N-8 SLBMs in place of the previous sixteen SS-N-6 SLBMs. The longer-range SS-N-8 SLBMs allowed the submarines to attack U.S. targets from Soviet waters. The Delta II was a lengthened version of the Delta I that carried four additional SS-N-8 SLBMs. All of these submarines have subsequently been retired.

The current Russian SSBN fleet includes the largest submarine ever built, the Typhoon class (Project 941, Akula), the Delta III class (Project 667), and the Delta IV class (K-51). Six Typhoon-class submarines were built. The Typhoons weigh 29,000 tons, are more than 540 feet long, have a beam width of 81 feet, and can carry twenty SS-N-20 (RSM-52) MIRVed SLBMs. The Delta III class (Project 667) sub weighs more than 13,000 tons, is more than 500 feet in length, has a beam of about 40 feet, and has the capacity to carry sixteen SS-N-18 (RSM-50) SLBMs. The Delta IV–class SSBN is essentially the same submarine as the Delta III but is designed to carry the SS-N-23 (RSM-54) SLBM instead of the SS-N-18. All of these submarines have reached or will soon reach the end of their service life. The Russians are currently building a new SSBN, the Borey class, which is projected to carry twelve missiles with an unknown number of reentry vehicles (*see* Russian Nuclear Forces and Doctrine).

French SSBNs

France's SSBN program began in 1969 with the Le Redoubtable class (later referred to as the L'Inflexible class). There were six SSBNs built. They weighed almost 9,000 tons, were 422 feet in length, and had a beam of almost 35 feet. The Le Redoubtable class was designed to carry sixteen M4/TN 70/71 SLBMs. The last boat was retired in 2002. The class was replaced by the Le Triomphant class. The French plan to build four new SSBNs, with the last one to be commissioned by 2008. Le Triomphant–class submarines weigh 14,335 tons, are 453 feet long, and have a beam of 41 feet. They will carry sixteen M45 SLBMs and will eventually carry a new missile, the M51 (*see* French Nuclear Forces and Doctrine).

Chinese SSBNs

China began its nuclear submarine program in the late 1960s. It has deployed one Type 092 (Xia class) SSBN. It is believed that this submarine carries the CSS-N-3/Julang-1 SLBM. The Type 092 has never left its coastal waters although it is considered operational. China is planning on building the first of four new SSBNs (Type 094) over the next few years, but progress may be slowed by problems in developing a new SLBM, the JL-2 (*see* Chinese Nuclear Forces and Doctrine).

—*Guy Roberts*

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SUBMARINE-LAUNCHED BALLISTIC MISSILES (SLBMS)

A submarine-launched ballistic missile (SLBM) is a long-range ballistic missile fired from the tube of a submerged submarine. The original concept for the SLBM has been attributed to a World War II German program that involved the installation of mortar tubes on the deck of a U-boat. The mortars were then fired at a land-based target while the tubes were still partially submerged. The Germans had test-fired this system by the end of the war. In 1955, a presidential committee in the United States recommended the development of a sea-based, intermediate-range ballistic missile with a range of 1,500 nautical miles. In 1957, the U.S. Navy began work on a ballistic missile with a range of 1,200 nautical miles, which subsequently became known as the Polaris missile program. The first successful underwater launching of an SLBM occurred on July 20, 1960, aboard the USS *George Washington,* the first ballistic missile submarine (*see* Submarines, Nuclear-Powered Ballistic Missile). At least four other nations have developed an SLBM capability: the United Kingdom, the Russian Federation, France, and China (*see* Strategic Forces).

The U.S. Navy has developed and deployed six versions of the SLBM: Polaris (A1, A2, and A3), Poseidon (C3), and Trident (C4, D5). Each of these missiles offered improvements over its predecessors in terms of range, accuracy, and throw weight. The most recent, the Trident II (D5), has a range in excess of 4,000 nautical miles and a payload capability almost twice that of its predecessor, Trident I (C4). The Trident II is configured to carry eight warheads (*see* Polaris SLBMs/SSBNs; Poseidon SLBMs/SSBMs; Trident SLBMs/SSBNs; United States Nuclear Forces and Doctrine).

The UK's SLBM capability is supported and complemented by the United States under the 1963 Polaris Sales Agreement, whereby the United States agreed to sell to the UK Polaris missiles (though without the warheads or reentry vehicles). The agreement was modified in 1982 to allow for the sale of the Trident II (D5) to the UK. The UK's Trident SLBMs are carried on four Vanguard-class SSBNs. As in the U.S. Trident II (D5) program, each SLBM is capable of carrying up to eight multiple independently targetable reentry vehicles (MIRVs). However, plans were announced in 1993 to limit the number of warheads carried from 192 to a maximum of 96 per submarine; this restriction has been further limited to 48 (*see* British Nuclear Forces and Doctrine).

The Russian SLBM program was developed by the former Soviet Union in conjunction with its SSBN program. The first SLBM, the SS-N-4 (its designation by the North Atlantic Treaty Organization [NATO]), was built in the late 1960s and deployed on the Golf-class submarine. It could not be fired submerged. Subsequent versions included the SS-N-5 and the SS-N-8, which offered increasingly improved capabilities and ranges. The current Russian SLBM program includes the SS-N-18, deployed on board the Delta III SSBN; the SS-N-23, deployed on board the Delta IV SSBN; and the SS-N-20, deployed on the Typhoon SSBN. These SLBMs are nearing the end of their service life and a new missile, the Borey, is being developed.

The United States and Russia have limited the number of deployed SLBMs based on limitations agreed upon in the Strategic Arms Reduction Treaties (START I and II). These treaties set forth the number of warheads each class of SLBM is authorized to carry, although it may be physically capable of carrying more. So, for example, the SS-N-18 is "attributed" with three warheads, the SS-N-23 with four, and the SS-N-20 with ten (*see* Russian Nuclear Forces and Doctrine; Strategic Arms Reduction Treaty; Strategic Arms Reduction Treaty).

The French SLBM is deployed on the Le Triomphant (S616) SSBN, which began replacing the L'Inflexible M4–class SSBNs in the 1990s. The submarine carries sixteen vertically launched M45 ballistic missiles. The M45 SLBM is a three-stage, solid-fueled rocket with a range of more than 10,000 miles and carries six multiple independently targetable reentry vehicles (MIRVs). By 2010, it is due to be replaced with the M51, which will carry up to twelve MIRVs and have an increased range in excess of 12,000 miles (*see* French Nuclear Forces and Doctrine).

China has one active SSBN, the Type 092 (Xia class), and one SLBM, the CSS-N-3/Julang 1, with a range of approximately 8,000 nautical miles. It carries one reentry vehicle. China has another SLBM under development, the JL-2. The range and payload of this new missile remain a matter of speculation (*see* Chinese Nuclear Forces and Doctrine).

—Guy Roberts

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SUFFICIENCY

Nuclear sufficiency is the idea that it is not necessary to match a nuclear-armed competitor in every measure of strategic nuclear capability, instead suggesting that a survivable nuclear retaliatory capability is key to deterrence. Nuclear sufficiency also takes into account the law of diminishing returns—that is, there is a point at which the ability to inflict additional death and destruction on an opponent serves no rational purpose and only represents a waste of resources that could be better used elsewhere.

Although strategists never advocated developing a capability to "make the rubble bounce," to use a pejorative phrase, sufficiency was a controversial issue. Those who advocated sufficiency as a criterion to size nuclear forces believed that it could lead to arms race stability. Critics of the idea believed that it failed to account for relative weaknesses in a nuclear force structure that might embolden opponents who might use different criteria to judge the survivability and effectiveness of a nuclear arsenal. Those who championed sufficiency often responded that their critics relied on highly improbable scenarios to point out weaknesses in nuclear force postures.

—Abe Denmark and James J. Wirtz

See also: Superiority

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SUMMIT MEETINGS

See Arms Control

SUPERIORITY

"Nuclear superiority" is a nebulous term that suggests that one side in a conflict has the ability to destroy an opponent's military capabilities with little fear of retaliation in kind. In the early years of the Cold War, the United States possessed nuclear superiority over the Soviet Union, but U.S. policymakers, in part owing to uncertainties about the size and location of Soviet nuclear forces, were never confident in their ability to destroy the Soviet nuclear arsenal. Nuclear superiority can be used to coerce other nations in diplomacy, as the United States did with the Soviet Union and its allies during the Cold War. President Dwight D. Eisenhower threatened North Korea and the People's Republic of China during the Korean War and the Offshore Islands crises in the 1950s, for example.

Nuclear superiority, however, is absent when both sides of a conflict posses a survivable nuclear capability. In terms of raw numbers and military capabilities, U.S. planners came to rely on the criterion of nuclear sufficiency to measure the adequacy of the U.S. nuclear arsenal. In other words, they came to see the nuclear balance in terms of the ability of the U.S. military to achieve its damage objectives against the Soviet Union in a second-strike situation. As both the Soviet Union and the United States gained secure second-strike forces, creating a situation of mutual assured destruction, many analysts came to believe that the concept of nuclear superiority had lost any military significance.

Some analysts postulated that one side might believe that it somehow possessed nuclear superiority—though now conceived of as a state of mind, not a battlefield reality. When both sides of a conflict possess a credible second-strike capability, nuclear superiority generally refers to the side which has managed to gain some sort of psychological advantage in a deterrence relationship. In these circumstances, nuclear superiority generally refers to the political ability and psychological will to threaten nuclear escalation in a conventional conflict or the opposing side's ability to deter such a threat.

—Abe Denmark and James J. Wirtz

See also: Cold War; Deterrence; Mutual Assured Destruction; Sufficiency

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SURETY

According to the U.S. Department of Defense, nuclear weapons surety includes the materiel, personnel, and procedures that contribute to the security, safety, and reliability of nuclear weapons and to the assurance that there will be no nuclear weapon accidents, incidents, or unauthorized weapon detonations. It is a system based on design, storage, and operating safety to: (1) minimize the possibility of accidents, inadvertent acts, or unauthorized activity that could lead to fire or high-explosive detonation; (2) minimize the possibility that fire could lead to a high-explosive detonation; (3) ensure the security of nuclear weapons; and (4) reduce or delay the possibility that an unauthorized detonation of a nuclear weapon would occur if it fell into the wrong hands. Nuclear surety is a critical step in providing negative control over nuclear weapons (guaranteeing that they will only be used when directed by legitimate authority) and in making weapons "safe."

To meet these surety objectives the Department of Energy (DOE) develops safety and security standards for nuclear warheads. It develops safe high explosives (explosives that will not detonate if faced with a high kinetic impact or high temperatures) for use in nuclear weapons and designs ways to prevent the dispersal of nuclear materials from a weapon in likely abnormal environments. DOE also works to insure that nuclear weapons designs incorporate the latest safety features.

One measure of nuclear surety is reflected by the term "one-point safety." A weapon is considered one-point safe if the probably of achieving a nuclear yield greater than 4 pounds of TNT in the event of a one-point explosion of the weapon's high-explosive initiator is less than one in a million.

—James J. Wirtz

See also: One-Point Detonation/One-Point Safe; Two-Man Rule

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SURPRISE ATTACK CONFERENCE

In February 1955, "Meeting the Threat of Surprise Attack," a top-secret report of President Dwight D. Eisenhower's Science Advisory Committee, concluded that with "no reliable U.S. early warning, our defense system is inadequate; therefore SAC [Strategic Air Command] is vulnerable and [the] U.S. is open to surprise attack." This and other reports that documented concerns about the development of Soviet intercontinental ballistic missiles led President Eisenhower in April 1958 to propose an international conference of technical experts to discuss measures that might prevent a surprise attack. The ten-nation Surprise Attack Conference was convened in Geneva in November 1958.

President Eisenhower's proposal followed a study prepared by a U.S. interagency working group that concluded that an effective safeguard to prevent surprise attacks would require an inspection system to monitor any agreed-upon limitations. At the conference, the Soviet Union resisted inspection of its military sites, and its delegation pushed for comprehensive disarmament as the best solution. The U.S. delegation tried to keep the focus on technical issues. Among its proposals was the development of specialized communications satellites for the enforcement of a possible treaty, deployment verification, and prevention of surprise attack. Another proposal, manned radar stations on the territories of the two countries to provide warning of a surprise attack, was rejected by the Soviets.

When the Surprise Attack Conference was suspended on January 21, 1959, the Western side was convinced that the Soviets would not agree to limit discussions to inspection and observation measures and that future negotiations would have to consider disarmament measures. Although the conference produced no agreement, it did address specific dangers arising from the arms race and encourage high-level dialogue between the United States and the Soviet Union.

—Patricia McFate

See also: First Strike; Reciprocal Fear of Surprise Attack

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SURVEILLANCE

Although the term "surveillance" describes any type of human or technical monitoring of an area or person of interest, it most often refers to systems intended to provide early warning of an air or missile attack. Space surveillance is an important component of national and theater ballistic missile defense systems.

The central node of the North American surveillance system is the North American Aerospace Defense Command (NORAD) located in the Cheyenne Mountain Operations Center in Colorado Springs, Colorado. Staffed by both U.S. and Canadian personnel, NORAD monitors data generated by the U.S. Space Surveillance Network that is comprised of satellites in Earth orbit, conventional radars, phased-array radars, and the Ground-Based Electro-Optical Deep Space Surveillance system (GEODSS). GEODSS telescopes can also image satellites of interest.

The United States also has deployed a variety of ground-based radars to monitor airspace along the periphery of the country. PAVE PAWS, for instance, is a radar system located at Beale Air Force Base in California, and Cape Cod Air Force Station in Massachusetts. The system can rapidly discriminate among scores of incoming warheads and debris while calculating missile-launch points and warhead-impact points. PAVE PAWS relays this data directly to controllers at Cheyenne Mountain.

In the future, the United States will increasingly rely on two satellite systems to provide early warning of air and missile attack: Space-Based Infrared High and Space-Based Infrared Low Satellites. The "SBIRS" system can track a missile from its launch point as it flies through space. It also can track aircraft, replacing conventional ground-based radars and Airborne Warning and Control System (AWACS) aircraft (officially the E-3 Sentry).

The United States employs a number of additional aerial surveillance aircraft, including the U-2S, several variants of the RC-135, Rivet Joint, the E-8 Joint Surveillance, Tracking, and Reconnaissance System (JSTARS), the WC-130H Hercules, the MQ-9 Predator unmanned aerial vehicle (UAV), and the RQ-4 Global Hawk UAV.

—James J. Wirtz

See also: Cheyenne Mountain; Early Warning; Missile Defense; North American Aerospace Defense Command; Space-Based Infrared Radar System

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SURVIVABILITY

Survivability is the characteristic of nuclear weapons that shows the degree to which they are able to withstand a nuclear strike—either by being mobile and thus difficult to target or by being "hardened" against a nuclear attack. Survivable nuclear weapons and their associated delivery systems have a greater chance of emerging intact following a nuclear attack and can be used (or threatened to be used) in retaliation. The maintenance of this "secure second-strike capability" based on survivable nuclear forces is considered to be a key component of a credible nuclear deterrent.

During the Cold War, the United States and the Soviet Union tried to build survivable nuclear forces. Both states hardened their land-based intercontinental ballistic missile (ICBM) silos to increase the likelihood that they would survive an attack. Because fixed ICBM silos are impossible to move, once the opponent's ICBM accuracies improved, they became vulnerable to destruction. As the Cold War progressed, ICBM survivability increasingly came to rely on policymakers' willingness to adopt "launch-on-warning" or "launch-under-attack" strategies (*see* Launch on Warning/Launch under Attack). Bombers are more survivable than ICBMs because they can be placed on airborne alert in times of crisis and avoid a nuclear strike. The most survivable nuclear forces are on deployed submarines. Because submarines are difficult to locate—in the absence of some technological breakthrough in ocean surveillance or treachery—it would be difficult for a state to destroy an adversary's ballistic missile submarine force by targeting likely open ocean operating areas. Today, submarine-launched ballistic missiles remain the most survivable basing mode for a deterrent force.

Ensuring that some nuclear weapons would survive an attack is critical to deterrence and contributes to crisis stability by eliminating an opponent's incentive to be first to use nuclear weapons in a crisis.

—Andrea Gabbitas

See also: Ballistic Missiles; Crisis Stability; Deterrence; First Strike; Second Strike

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T

TACTICAL NUCLEAR WEAPONS

Nonstrategic nuclear weapons have gone by various names. Primarily stationed in Europe, the Far East, and at sea, they have been known at different times as battlefield nuclear weapons, nonstrategic nuclear weapons (NSNW), theater nuclear weapons, theater nuclear forces (TNF), intermediate-range nuclear forces (INF), short-range nuclear forces (SNF), long-range theater nuclear forces (LRTNF), substrategic nuclear weapons, and tactical nuclear weapons (TNW). Tactical nuclear weapons were a central military and political concern during the Cold War.

It is difficult to define exactly what constitutes a nonstrategic nuclear weapon. Traditional attempts at delineating between types of nuclear weapons—range, delivery vehicle, explosive power, and the like—are overly simplistic and outmoded approaches that miss many of the nuances that surround the deployment and use of these weapons. Some definitions of tactical weapons list them as low-yield, short-range weapons for use on the battlefield rather than against countervalue targets such as cities. The best way to define them may be "by exclusion." That is, anything not captured by strategic arms control negotiations is, by default, nonstrategic. Another perspective holds that *any* nuclear weapon must be strategic, given its potential for physical devastation and political chaos. A third view suggests that only one's adversary can define whether a weapon is strategic or nonstrategic, based on its perceived use.

The key purpose of TNW, from a U.S. perspective, is to deter coercion and aggression against the United States and its allies. To do this, the United States built a massive arsenal during the Cold War, eventually numbering more than 20,000 tactical nuclear weapons in addition to some 15,000 strategic warheads. The Soviet Union had even more nonstrategic nuclear weapons in its arsenal.

The second cornerstone of U.S. TNW policy was to provide a nuclear presence in Europe to support the North Atlantic Treaty Organization (NATO) as the essential link between the European and North American allies. These weapons were part of NATO's "Triad": conventional forces, tactical nuclear weapons in theater, and U.S. and British strategic nuclear systems. NATO's strategic concept still calls for the continued presence of such weapons in Europe in order to maintain the transatlantic deterrent link to the United States and for purposes of creating political and military uncertainty in the mind of any potential opponent.

Their third purpose became evident in the 1990s: to deter the use of weapons of mass destruction (WMD) more broadly. During the Gulf War, and again in the first years of the twenty-first century, the U.S. government made it clear, for example, that any WMD use by an adversary would result in a "prompt, devastating retaliatory blow" in which no weapons would be ruled out. It was widely understood by both sides in the Gulf War that this meant nuclear weapons, although some U.S. officials denied they meant to threaten Iraq with nuclear retaliation.

Historically, nuclear arms control has focused on long-range strategic systems, but the Soviet Union always tried to include U.S. TNW in arms control talks. From the Soviet perspective, nuclear weapons stationed in Europe and aimed at Russian soil should not be considered "nonstrategic." The United States, by contrast, consistently rejected that position, and tactical nuclear forces were largely left off the negotiating table until the 1987 Intermediate-Range Nuclear Forces (INF) Treaty.

The United States is trying to decide what value such weapons provide to its own security and considering whether to keep or eliminate its small remaining stockpile. Although the United States has substantially reduced its reliance on these weapons since 1991, Russia appears to be adjusting its national security doctrine to place even greater emphasis on nuclear weapons—including smaller, "tactical" warheads. With thousands of these warheads and several delivery systems for them, Russia has a large asymmetrical advantage in numbers of TNW and has been unwilling to implement the 1991 Presidential Nuclear Initiatives (which eliminated most U.S. tactical nuclear weapons) or to discuss TNW in a separate, formal arms control forum. Yet the 1997 Helsinki Agreement indicated that Russia was willing to talk about TNW to the degree that it benefits them or is linked to broader strategic issues. Russia's huge arsenal of tactical nuclear weapons is particularly unsettling given worries about Russia's future and the possibility of the loss or sale of these weapons (*see* Presidential Nuclear Initiatives).

Presidential George H. W. Bush's nuclear initiatives in the fall of 1991 called for the withdrawal and eventual elimination of most U.S. TNW around the globe, including the cancellation of all related research and development programs. The Clinton administration furthered this decision by eliminating naval nuclear capabilities on surface ships entirely. America's remaining nonstrategic capabilities are now limited to gravity bombs delivered by tactical aircraft and nuclear Tomahawk Land-Attack Missiles (TLAM-Ns) delivered by submarine. The latter are not routinely deployed with the fleet. Precise numbers of warheads are classified, but the total U.S. force of bombs and TLAM-Ns has been drastically reduced since the Cold War. A significant proportion of these remaining weapons are still based in Europe, and several European states maintain nuclear delivery plans in their NATO war orders that would depend on U.S. warheads.

Key issues for the existing nonstrategic nuclear weapons force posture include deciding whether the United States should keep its current levels of TNW or to reduce the numbers further, determining the purposes for these remaining weapons, and deciding where to station them. The perceived battlefield use and utility of these weapons has dropped significantly since the end of the Cold War. Nevertheless, the U.S. government maintains the policy that it must be able to deliver on its threat to use nuclear weapons in dire circumstances. And there exist some military operations that can only be accomplished using the particular effects that nuclear weapons provide. For those reasons, the U.S. military maintains a small arsenal of tactical nuclear weapons and the plans for their use. The 2001 Nuclear Posture Review, in fact, called for continued research and development efforts on smaller, more usable nuclear weapons (*see* Nuclear Posture Review).

One of the biggest challenges to planners in today's increasingly complicated world is determining whether nuclear weapons are appropriate in response to enemy chemical or biological weapons use. The maintenance of a nuclear force projection capability also requires the platforms, support infrastructure, and trained and certified crews to be available or maintained at an appropriate level of readiness.

—Jeffrey A. Larsen

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TELEMETRY

While undergoing flight-testing, missiles, missile stages, and missile warheads send performance data to a ground station so that engineers can determine how well the components and systems are working. This information is called telemetry. Telemetry includes data on structural stress, thrust, fuel consumption, guidance-system performance, and the ambient environment. Intercepted and decrypted telemetry can provide information about a system's guidance system operation, fuel usage, staging, warhead characteristics, and other parameters vital for understanding the operational characteristics of a delivery system. This data, if intercepted by another country, can help the intelligence community determine the system performance, range, staging, warhead size, and capability of an adversary's missile. Telemetry thus allows engineers to establish the operational characteristics of a missile system.

Telemetry intelligence is collected by a variety of platforms: Aircraft, ships, ground stations, and satellites are all used. The ability to collect unencrypted telemetry data was a major verification tool for the United States in ensuring Soviet compliance with various arms control agreements. When the Soviet Union began to encrypt this telemetry data, especially on the SS-24 and SS-25 intercontinental ballistic missile (ICBM), the United States pushed for an annex to the treaties stating that telemetry must remain unencrypted. During the second round of Strategic Arms Limitation Talks (SALT II), encryption was viewed as a violation of SALT I and the 1974 Vladivostok Accord and became a major source of contention between the two superpowers.

During Senate hearings on SALT II, verification concerns, especially the issue of telemetry access, wrecked all hopes of ratification. The Jimmy Carter administration was forced to reveal that the loss of intelligence-gathering facilities in Iran had led to a loss of Soviet telemetry data. This issue, also referred to as "data denial," was one of four obstacles that held up the 1991 Strategic Arms Reduction Treaty (START I) during its final phases. Part of the problem stemmed from differences in U.S. and Soviet missile testing. The United States tests its ballistic missiles over open ocean, making its data more available to interception. Many Soviet tests took place wholly within its own territory, thus limiting U.S. access to that data.

START I bans data denial and includes obligations to broadcast such data and to exchange tapes of the data after flight tests. The provisions apparently met U.S. data requirements and facilitated monitoring various qualitative treaty limits. During the first year after START I entered into force, the parties demonstrated their telemetry tapes, as required by the treaty, and installed playback equipment on each other's territory. Although they regularly exchange tapes after conducting missile flight tests, both sides have raised questions about the completeness of the other's telemetry tapes.

—*Gilles Van Nederveen*

See also: Data Exchanges; Reconnaissance Satellite; Verification

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TERMINAL PHASE

"Terminal phase" generally refers to the final segment of a ballistic missile's flight path, in which the missile and its warheads travel toward the earth at very high speeds to their targets.

Modern intercontinental ballistic missiles (ICBMs) reach speeds of well over 2,000 miles per hour as they reenter the atmosphere. Because of the high speeds involved in reentry, the terminal phase of an ICBM usually lasts less than a minute. For this portion of the missile's trajectory, the warhead is protected by a cone-shaped reentry vehicle.

High reentry speeds pose significant challenges to engineers attempting to develop terminal-phase ballistic missile defenses (BMDs). Modern efforts rely on hit-to-kill interceptors (also known as kinetic-kill interceptors). Although decoys are stripped away by the atmosphere in the terminal phase of reentry, simplifying the problem faced by defensive systems, terminal-phase defenses destroy warheads over friendly territory, posing chemical, radiological, or biological hazards.

—*Abe Denmark*

See also: Decoys; Missile Defense; Reentry Vehicles

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THEATER HIGH ALTITUDE AIR DEFENSE (THAAD)

Theater High Altitude Air Defense (THAAD) is a missile defense program of the U.S. Army, under way since 1992, to defend against attack by short- or medium-range ballistic missiles at significant distances from the defended area. A THAAD battery will consist of nine truck-mounted launch vehicles, each carrying eight missiles, two mobile tactical operations centers, and an X-band ground-based radar for surveillance and tracking of target missiles.

THAAD will be rapidly deployable: All elements are transportable by cargo aircraft and can be driven to appropriate locations within a combat theater.

THAAD is the only missile defense system designed to destroy ballistic missiles either inside or above the atmosphere. Exoatmospheric intercept reduces the risk that debris from the missile or its chemical, biological, or nuclear warhead will cause damage at ground level. Combining endoatmospheric and exoatmospheric intercept capability makes development of enemy countermeasures more difficult. THAAD was designed to protect deployed military forces, but it can also protect population centers as part of a layered ballistic missile defense system.

THAAD flight testing occurred at the White Sands Missile Range, New Mexico, from 1995 to 1999. Following several test failures resulting mainly from production defects, THAAD achieved two consecutive target intercepts in tests in 1999. Using the results from these risk-reduction tests at White Sands, engineers will produce an operational design that is expected to be flight tested in 2004 and to enter production in 2007.

Successful development of THAAD components has led to scaled-up designs for national missile defense, and THAAD now serves as the ground-based mid-course interceptor of the U.S. ballistic missile defense system.

—*Roy Pettis*

See also: Ballistic Missile Defense Organization; Missile Defense; Theater Missile Defense

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THEATER MISSILE DEFENSE

Theater missile defense (TMD) is a system of surveillance, communication, and weaponry designed to protect limited geographical regions outside of the United States. The overall mission of TMD, as defined in the U.S. Department of Defense TMD Mission Need Statement (MNS), is "to protect U.S. forces, U.S. allies, and other important countries, including areas of vital interest to the U.S., from theater missile attacks." Theater missiles include ballistic missiles, cruise missiles, and air-to-surface guided missiles assigned to targets within a theater or capable of attacking such targets.

The need for TMD is created by the continuing proliferation of ballistic and cruise missiles. Potential U.S. adversaries possess hundreds of missile launchers and thousands of missiles. Contributing to the complexity of this menace is the wide variety of available warheads that can carry high explosives, chemical agents, biological agents, or fissile materials.

Because no single system can protect an area from all theater missile threats, the MNS concluded that TMD must act as a fully integrated system. With this in mind, it identified four pillars of TMD: passive defense (PD); battle management/command, control, communications, computers, and intelligence (BM/C4I); attack operations (AO); and active defense (AD).

Passive defenses bring together capabilities designed to improve the inherent survivability of friendly forces and assets. This includes developing and deploying early warning systems to detect impending attack, hardening friendly forces against missile attack, dispersing forces to limit the effectiveness of an attack, concealing assets from overhead or ground surveillance, and quickly reconstituting operational effectiveness following an attack.

Battle management/command, control, communications, computers, and intelligence is central to ensuring an effective TMD. It involves developing communication systems and procedures to link early-warning and missile-tracking data to commanders and missile defense systems so that commanders can make the decision to engage incoming warheads. The air force has been designated by the Department of Defense as the executive agent for theater air defense BM/C4I. As the executive agent, it is responsible for constructing a theater air defense BM/C4I architecture that will provide U.S. combat commanders with a flexible system designed to integrate the required joint forces with combat theater missile threats. Currently, the air force is responsible for space-based theater ballistic missile (TBM) launch detection and warning. Space-based ballistic missile launch detection is accomplished by Defense Support Program satellites. The data are sent to data-processing centers that forward the information in real time to the responsible commands and operational units.

Attack operations are primarily counterforce undertakings that focus on the destruction of the enemy's capability to launch missiles. For TMD, counterforce options have three windows of opportunity. The first is the infrastructure in which the missiles, warheads, and launchers are designed, produced, and stored. An attack against this target can have a significant, albeit delayed, effect on the opponent's capabilities. The second is the forward support logistics infrastructure where the enemy moves its theater missile systems prior to hostilities. This also can be a lucrative target that is relatively easy to detect, given the large signature it generates when supporting forces in crisis or wartime. Last is the launch phase, when the missile, warhead, and launcher are moved to the firing point and launched. This is probably the most difficult part of the counterforce mission because of its urgency and the difficulty involved in detecting individual delivery systems once they are deployed to operational units (*see* Counterforce Targeting).

Active defenses focus on intercepting incoming theater missiles in flight and destroying them. The United States is planning a highly diversified system of defenses that can destroy missiles and warheads in various stages of flight. Multiple systems have been under consideration for this mission for years. Various concepts have undergone continuous development and refinement, and testing has eliminated some and validated others. Officials envision a number of active defense programs to provide a layered defense of the U.S. homeland, deployed forces, and allied states.

The Patriot Advanced Capability 3 (PAC-3) system will defend troops and fixed targets from cruise missiles and aircraft as well as from short- and medium-range ballistic missiles. The PAC-3 is a terminal defense system that provides concentrated defense against "point" targets. It offers low-tier, ground-based protection by employing mobile radar, C4I, and missile batteries. Each PAC-3 battery is a mobile launching station that can carry sixteen missiles. Patriots were first used in the 1991 Gulf War, and PAC-3 was combat-tested in Operation Iraqi Freedom in 2003.

The Theater High Altitude Area Defense (THAAD) system is an upper-tier, ground-based system that will defend large areas against longer-range theater missiles at higher altitudes, both inside and outside the atmosphere. It comprises a mobile launcher carrying four missiles, a ground-based radar, and a BM/C4I system. THAAD will be able to engage almost all theater ballistic missiles. Its ability to intercept targets at long range means that, under most conditions, it will be able to fire an interceptor at an incoming missile, assess the success of that engagement, and, if necessary, fire a second missile.

The U.S. Navy will provide TMD capabilities to areas that are not easily or quickly accessible by land. It has deployed its Aegis air defense system for fleet protection since the 1970s and plans to upgrade those capabilities to counter ballistic missiles, as well. The navy has been able to achieve upper-tier defense capabilities with the Aegis ballistic missile defense (BMD) system (called the navy theater-wide system during the Bill Clinton administration), which is an upgraded version of the Aegis radar and Standard missile defense systems. BMD builds upon modifications to the existing Aegis ships and the Standard air defense missile. This system will use Standard missiles, modified for intercepts outside the atmosphere, working in tandem with the Aegis combat system. Plans to create a navy area defense (NAD) system to provide a defensive capability against short- and medium-range theater ballistic missiles in the atmosphere during their terminal phase were canceled early in the George W. Bush administration.

In addition to these programs, the U.S. military is designing a wide variety of other systems that will better defend against hostile missiles. The Medium-Range Extended Air Defense System (MEADS) is an upgrade of the PAC-3 system that will provide improved protection against short-range ballistic missiles as well as against aircraft and cruise missiles. MEADS is a joint venture between the United States, Germany, and Italy. Additionally, the United States is developing an Airborne Laser aboard a modified Boeing 747 that is designed to destroy enemy ballistic missiles during the boost phase. Plans for a space-based laser have been scaled back to a general research program.

—*Abe Denmark*

See also: Ballistic Missile Defense Organization; Missile Defense; Theater High Altitude Air Defense; United States Navy

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THERMONUCLEAR BOMB

A thermonuclear bomb (also known as a fusion, hydrogen, or H-bomb) is a weapon that derives the majority of its explosive power from thermonuclear fusion. The earliest thermonuclear weapons were derived from pure fission, but modern weaponry derives its power from both fusion and fission reactions. All fusion weapons must have a fission explosion to make them work. There are three general types of fusion weaponry: boosted fission, staged radiation implosion, and "Sloika" weapons.

The earliest thermonuclear weapons were boosted fission weapons. By using a small amount of deuterium-tritium gas within the fissionable core, it was possible to significantly increase the yield of an atomic weapon (*see* Deuterium; Tritium). When deuterium-tritium becomes hot enough from the fission explosion, it produces a fusion reaction that nearly doubles the yield, even though only about 1 percent of the yield is from fusion. Although this method is effective, it is expensive. Tritium also has a high decay rate (nearly 6 percent a year); therefore, weapons that incorporate tritium require frequent replenishment to replace the tritium that has decayed.

The staged radiation implosion weapon (also known as a Teller-Ulam weapon, named after designers Edward Teller and Stanislaw Ulam) was first designed in the 1950s. This class of nuclear weapon reduces the weight of the bomb by reducing the amount of uranium and plutonium needed to produce a given yield. The weapons are set up in a three-stage fission-fusion-fission design. The primary charge of fissionable material is detonated, setting off a physically separated package of fusion fuel (stage two). X-rays from the primary explosion compress the fuel through a process known as "radiation implosion." The force from the fusion second stage is then used to detonate an even larger third stage of material. Theoretically, with staged weapons an almost unlimited yield is possible. The Soviet Union's Tsar Bomba test of 1961 was a fission-fusion-fission design and produced a yield of somewhere between 50 and 100 megatons.

The "Sloika" design is named after a Russian pastry. The concept actually predates the staged radiation implosion designs. The design uses a series of concentric shells, each encased around the one before it. The center contains a fission primary of Uranium 235 or Plutonium 239 with an optional layer of Uranium 238. Surrounding the core is a lithium-6 deuteride-tritide cover that in turn is encased by a high-explosive shell. The Sloika can produce a tenfold boost in yield. U.S. designers never pursued this design beyond the concept phase because they felt that it was not destructive enough for the amount of fuel needed.

—*Zach Becker*

See also: Fission Weapons; Fusion; Hydrogen Bomb; Manhattan Project; Nuclear Weapons Effects; Pit; Primary Stage

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THREE MILE ISLAND

Three Mile Island is a nuclear generating plant that takes its name from an island on the Susquehanna River near the Pennsylvania capital of Harrisburg, where the plant is located. It generated electricity for the Metropolitan Edison Company. On March 28, 1979, it suffered a partial meltdown accident that, though not life threatening, created a public relations nightmare and set back growth in the nuclear power industry in the United States.

Three Mile Island consisted of two units (power-generating reactors). Unit 1 was undergoing its annual shutdown for inspection and refueling at the time of the accident. Unit 2 was a new reactor built in 1978 and designed by the Babcock and Wilcox Company. It used pressurized water to cool and convey heat from the atomic core to the steam tur-

The four cooling towers at the Three Mile Island nuclear plant were shut down after a leak developed in the cooling system, March 28, 1979. (Bettmann/Corbis)

bines. The accident began in Unit 2 during a routine maintenance operation, when air introduced into the cooling system caused a shutdown of the cooling-water intakes.

The emergency shutoffs and pressure relief valves operated properly, and dampening rods fell into the core to end most of the nuclear reaction. Because of an earlier maintenance error, however, the valves to the emergency pumps to cool the turbine had been left closed, so barely enough water was available to keep the core covered and cool. Problems began to cascade as operators failed to interpret warning indicators correctly, leading to a situation in which the twenty-story containment building eventually stood as the last line of defense against a catastrophic radiation release. Engineers misjudged that the leaking water was turbine coolant when in fact it was reactor coolant and radioactive. The leak uncovered nuclear fuel, contaminating the coolant water and ultimately the containment building. The reactor heat rose, destroying the cooling rods and resulting in a melted mass of dangerous radioactive fuel. The hydrogen and oxygen present in the reactor created a bubble that could have led to an explosion. By April 4, scientists and engineers realized that the amounts of these materials had been miscalculated, and by that evening the plant was back under control. The containment building held, and the core did not melt down.

Officials failed to keep the public well informed about the nature of the accident. When the seriousness of the accident was recognized, mildly radioactive waste coolant water was emptied into the Susquehanna River. Scientists publicly disagreed with each other about the accident and its implications. Based on confusing information from "experts," 14,000 local residents self-evacuated. The governor advised all pregnant women and preschool children within 5 miles of the plant to evacuate and others to seek local shelter. A rumor spread of the likelihood of an explosion based on the presence of a hydrogen bubble inside the reactor. President Jimmy Carter, a former naval officer with nuclear experience, visited the plant, and scientists realized that the danger had been overestimated.

Unit 2 of Three Mile Island was closed permanently following the accident. This near disaster caused a hiatus in nuclear reactor construction in the United States that has lasted into the beginning of the twenty-first century.

—*Frannie Edwards*

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THREE-PLUS-THREE PROGRAM

The three-plus-three program was a missile defense program announced by the William Clinton administration in 1996. It called for creating the infrastructure to develop a national missile defense (NMD) system in three years, with a capability to deploy the system three years after a development decision had been made. The 1996 timeline called for a presidential decision in 2000 on whether to begin deployment. The goal of NMD was to protect the United States against a limited "rogue" nation's ballistic missile attack and accidental or unauthorized ballistic missile launches from other nuclear-capable states. As part of this program, the Clinton administration supported research and development of a variety of land-, air-, and sea-based missile defense systems without making a commitment to any specific missile defense architecture.

The Clinton administration proposed four criteria to use in making a deployment decision: the technological feasibility of NMD, the cost, the impact of a deployment decision on U.S. diplomatic relationships, and the extent of the ballistic missile threat to the United States. In September 2000, President Clinton announced that he was deferring a decision on NMD deployment so that the next administration could take a fresh look at the issue. It was assumed that such a presidential decision would delay deployment of an NMD system until 2004 at the earliest.

Research and development for the three-plus-three program remained compliant with the Anti-Ballistic Missile (ABM) Treaty. It was understood that a deployed NMD system would require amendments to the treaty, but an attempt was made to keep the number of sites and interceptors consistent with treaty obligations. Russia resisted any change to the treaty, maintaining that defense of national territory would undermine strategic stability. The George W. Bush administration's missile defense system incorporates components developed by the Clinton administration under its three-plus-three program.

—*Steven Rosenkrantz*

See also: Anti-Ballistic Missile Treaty; Missile Defense

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THRESHOLD STATES

At the center of the nuclear nonproliferation regime stands the Nuclear Nonproliferation Treaty (NPT), essentially a bargain between the nuclear powers and the nonnuclear states to halt the proliferation of nuclear weapons. Proliferation can occur both horizontally (the acquisition of nuclear arms by nonnuclear parties) and vertically (the further development, production, and deployment of nuclear weapons by the nuclear parties). The NPT seeks to prevent both types of proliferation. Signed in July 1968, it now has every major country as a member state except for India, Israel, Pakistan, and North Korea (the latter withdrew in 2003). Under the NPT, the non–nuclear weapons states agreed not to acquire nuclear weapons and to accept a system of safeguards over their peaceful nuclear activities in exchange for nuclear material, equipment, and technology for peaceful purposes to be supplied by the nuclear parties (especially the United States and the Soviet Union).

Under this unique arrangement, the nonnuclear states are permitted to use nuclear energy for scientific and commercial uses. Weapons production, however, is a flagrant violation of the NPT. Several states have secretly developed nuclear technology for possible weapons production while staying well short of the "threshold" of weapons assembly and testing. There have been three distinct generations of threshold states since the dawn of the nuclear era.

During the first phase, which spanned from 1945 until 1968, when the NPT was signed, Western industrial countries such as Sweden, Italy, and Australia took decisive steps toward developing nuclear weapons but never crossed the threshold of nuclear bomb production. Ultimately, they abandoned their nuclear aspirations. In contrast, after the United States and the Soviet Union produced nuclear weapons, the United Kingdom, France, and China blew past the nuclear threshold and built the bomb. As a result, these five are the only nuclear weapons states recognized by the NPT.

The second generation of nuclear threshold states moved toward nuclear weapons acquisition after the NPT was signed and before the Cold War ended. The most prominent threshold states that started nuclear arms programs but stopped short of the brink of bomb production were Argentina, Brazil, Taiwan, and South Korea. A combination of U.S. security assurances and multilateral nonproliferation diplomacy succeeded in reversing nuclear proliferation in these cases. In contrast, India, Pakistan, Israel, and South Africa had manufactured nuclear weapons by the end of the Cold War (*see* Indian Nuclear Weapons Program; Israeli Nuclear Weapons Capabilities and Doctrine; Pakistani Nuclear Forces; South African Nuclear Weapons Program; South Korean Nuclear Weapons Program).

Today, nonproliferation policymakers are grappling with a third generation of threshold states: Iraq, Iran, and North Korea. The 2003 U.S.-led war against Saddam Hussein's regime in Iraq removed that country from the problem list, but Tehran and Pyongyang remain poised on the threshold of nuclear weapons production—indeed, the latter might already have fabricated two or more nuclear weapons (*see* Iranian Nuclear Weapons Program; Iraqi Nuclear Forces and Doctrine; North Korean Nuclear Weapons Program).

It is difficult to predict which countries will make up the next generation of nuclear threshold states. Future developments will depend largely on the conduct of the existing nuclear weapons states and on how the international community deals with the existing threshold states.

—Peter Lavoy

See also: Non-Nuclear Weapons States; Nuclear Nonproliferation Treaty

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THRESHOLD TEST BAN TREATY (TTBT)

Following ratification in 1963 of the Limited Test Ban Treaty (LTBT), which prohibited the testing of nuclear weapons in outer space, under water, and above the ground, the United States and the Soviet Union were limited to conducting their nuclear weapons tests underground. The LTBT, however, did not limit the size of these underground tests. In 1974, in the Threshold Test Ban Treaty (TTBT), the United States and the Soviet Union agreed to limit the yield of underground nuclear tests to no more than 150 kilotons. Although both sides noted that verification would be technically difficult because on-site verification was not permitted, the 150-kiloton limit was seen as one way to constrain the ability of both sides to field new nuclear weapons designs.

As a result of the verification problems, the TTBT was never ratified, even though both parties declared their intention to abide by the 150-kiloton limit. From 1976 to 1990, the United States continually accused the former Soviet Union of conducting nuclear weapons tests that violated the limit.

Following six rounds of Nuclear Testing Experts Meetings, the United States and the Soviet Union opened the Nuclear Testing Talks in 1987 with the goal of negotiating a new verification protocol to the TTBT. The parties reached agreement in May 1990 after conducting several rounds of negotiations and a joint verification experiment. The new verification provisions allow for on-site inspection of test areas, in-country seismic monitoring of tests, and placement of yield estimate instrumentation in the test area. The amended TTBT is automatically renewed at five-year intervals unless either party notifies the other of its intention to terminate its participation. No issues have arisen with this treaty, especially since 1992, when each party announced a self-imposed moratorium on nuclear testing.

—Guy Roberts

See also: Arms Control; Limited Test Ban Treaty; Nuclear Test Ban; Peaceful Nuclear Explosions Treaty; Underground Testing

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TINIAN

Tinian is one of the Mariana Islands in the Philippine Sea near Guam and Saipan. It was occupied by the Japanese during World War II and taken by the Americans in the summer of 1944. It is best known as the departure point for the planes that dropped the atomic bombs on Hiroshima and Nagasaki in August 1945.

Occupying just 50 square miles, the low, flat island is about 12 miles long north to south and is located two and a half miles south of Saipan. During World War II, it was covered with sugarcane.

The island was taken in an amphibious assault by the United States against well-entrenched Japanese defenders in a battle that took place from July 24 until August 1, 1944. Casualties included 6,050 Japanese who died defending the island and 290 U.S. Marines who died in the conquest. Afterward, Tinian became an important airfield for the planned attacks on the Japanese home islands. Its flat terrain offered space for six 8,500-foot runways to accommodate the B-29s needed for the planned bombing of Hiroshima and Nagasaki.

By the summer of 1945, one year after its conquest, Tinian had been developed as an air base. A squadron of advanced long-range B-29 bombers was moved to Tinian and conducted practice runs to Japan, dropping orange "pumpkin bombs" to simulate the atomic weapons they would ultimately carry. Both the *Enola Gay,* carrying the bomb named "Little Boy" to Hiroshima on August 6, 1945, and the *Bockscar,* carrying "Fat Man" to Nagasaki on August 9, 1945, were launched from Tinian.

Following World War II, the Mariana Islands became U.S. trust territories. Tinian is occupied by its original inhabitants.

—*Frannie Edwards*

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TITAN ICBMS

The Titan series of intercontinental ballistic missiles (ICBMs) was developed in 1955 as a redundant system to the Atlas ICBM. The two series were developed and deployed simultaneously. The Titan I, a two-stage missile with liquid propellant made of kerosene and liquid oxygen, was deployed in 1962. It was armed with either the W-38 or the W-49 warhead, both of which had yields of approximately 4 megatons. Although the Titans were the first ICBMs to be placed in underground hardened shelters, they had to be lifted to the surface by elevator prior to launch. In all, fifty-four were deployed throughout the western United States. They were decommissioned in 1965.

The Titan II ICBM, which came into service in 1963, was the largest missile ever fielded by the U.S. Air Force. Longer and heavier than its predecessor, it boasted an improved engine, different fuel (50 percent hydrazine and 50 percent dimethylhydrazine), and a larger warhead (the W-53, with a 9-megaton yield—the most powerful nuclear weapon ever produced by the United States). Unlike the Titan I, the Titan II did not need to be lifted to the surface to fire but could be launched from the safety of its silo. The Titan II remained in service until 1987, when it was finally retired from the active force.

Perhaps the Titan's greatest achievement was its role in space flight. The Titan was the rocket used for the Gemini series of manned space flights and is still used today to launch weather and communication satellites.

—*Zach Becker*

See also: Ballistic Missiles; Intercontinental Ballistic Missiles; Silo Bains; United States Nuclear Forces and Doctrine

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TOUS ASIMUTS

French for "every point on the compass," *tous asimuts* referred to France's nuclear strategy to deter danger from all directions. During the 1960s, French nuclear doctrine and its *Force de Frappe* ("Strike Force") were intended to increase French independence from a U.S.-dominated North Atlantic Treaty Organization (NATO). French officials also believed that reliance on U.S. nuclear extended deterrent guarantees was unreliable and potentially dangerous, especially in light of U.S. involvement in Vietnam. French president Charles de Gaulle believed that France's nuclear weapons gave it the stature of a great power, and he attempted to use this status to influence NATO policy and political events in Europe.

The nuclear doctrine that flowed from these strategic objects was called "tous asimuts." French nuclear weapons would not be directed solely against the Soviet Union, or against the threat of a Warsaw Pact conventional attack across the inner-German border, but in all directions, against all potential threats. French strategists argued that given the increasingly chaotic international situation in the 1960s, it was important that France maintain an independent nuclear force so that France could be a sanctuary in the event it decided not to participate in a future European conflict.

Tous asimuts created a major challenge to NATO's policy of extended deterrence. France lacked the delivery systems with the range necessary to undertake its new doctrine. French leaders hoped the policy would help to break up the bipolar nature of the Cold War standoff in Europe, but French nuclear doctrine did little to change the fundamental balance of terror that dominated European politics and military strategy during the second half of the twentieth century.

—*James J. Wirtz*

See also: Cold War; Extended Deterrence; French Nuclear Forces and Doctrine; North Atlantic Treaty Organization

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TRANSPORTER-ERECTOR-LAUNCHER

A transporter-erector-launcher (TEL) is a self-propelled vehicle that transports and erects a missile to the vertical position in order to launch it. In the 1950s and 1960s, intercontinental ballistic missiles (ICBMs) were too heavy and too susceptible to vibration damage while being moved on a transporter. Development of a mobile ICBM was thus a high priority for both the United States and the U.S.S.R. The Soviet Union had a string of failures with its SS-14 intermediate-range ballistic missile (IRBM) and its SS-15 ICBM, which were mounted on a tracked tank chassis. These two systems were never widely deployed because the tracked TELs could barely carry the weight of the massive ICBMs. Only with the development of the SS-16 ICBM and the SS-20 IRBM did the Soviets achieve their goal of a wheeled TEL.

The TEL carries not only a missile that is environmentally protected, but also electronics to monitor the missile, alignment equipment, and communications links to receive orders from headquarters. To increase the pre-launch survivability of the missile, the TEL must be able to traverse a variety of terrain types and move quickly over a large distance, especially to disperse to operating areas when placed on alert or during a crisis.

Russia currently uses a slightly larger TEL for its SS-25 and SS-27 ICBM force. Other nations have developed but not deployed mobile ICBM TELs. The United States developed a complex vehicle for the single-warhead Midgetman ICBM that could withstand a nuclear blast by hugging the ground. The MX missile also could have been TEL mounted, but it was never deployed in this configuration. Other short-range missile systems, most notably the Scud missile, often are mounted on trucks or simple tracked vehicles.

—*Gilles Van Nederveen*

See also: Ballistic Missiles; Mobile ICBMs

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TRIAD

Developed in the early 1960s, the term "Triad" referred to the maintenance of three types of nuclear delivery systems in the United States: intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and long-range bombers. Each leg of the Triad was supposed to be capable of surviving a Soviet first strike and inflicting a retaliatory strike called for by U.S. nuclear war plans. The concept has been redefined in the 2002 Nuclear Posture Review. The "new Triad" consists of offensive nuclear forces and long-range conventional precision-strike systems (which encompasses the "old" Triad), missile defenses, and a defense infrastructure capable of supporting a nuclear arsenal for the indefinite future. The new

Triad concept acknowledges that deterrence might fail in a global environment where terrorists or rogue states are hell-bent on aggression and that maintenance of an assured second-strike capability is not a critical factor in deterring war. It supports a capability to conduct preventive or preemptive strikes against acute threats. Implicit in the concept is an enhanced strategic command and control system and a shift away from threat-based, deliberate planning toward a capabilities-based, adaptive planning approach to meet strategic threats (*see* Preemptive Attack; Preventive War).

During the 1950s, American strategic doctrine assumed that U.S. nuclear threats were highly credible. Several academic strategists, such as Albert Wohlstetter at the RAND Corporation, however, believed that the so-called balance of terror was fragile because it rested not on a U.S. first strike but on the ability to launch a second strike after absorbing a Soviet nuclear attack. Concerns were raised about a potential "nuclear Pearl Harbor"—a disarming surprise first strike by Soviet forces that would destroy the United States but leave Russia intact. Wohlstetter and his contemporaries began suggesting that it was not the overall size of the U.S. nuclear arsenal that was important, but the forces that would survive a Soviet first strike.

To achieve this secure second-strike capability, and to ensure that it would be available under all circumstances, planners and analysts quickly recognized the benefits provided by a nuclear Triad. Each leg of the Triad would be able to inflict "assured destruction" of the Soviet Union in a second strike, which was defined by Secretary of Defense Robert McNamara as a strike that killed 30 percent of the Soviet population and destroyed 70 percent of its industry. Deploying the U.S. nuclear arsenal would complicate Soviet attack options and prevent the loss of the entire deterrent force due to a Soviet defensive breakthrough, a security compromise, or a catastrophic failure across an entire type of weapons system. The assured destruction criteria articulated by McNamara also allowed him to cap the size of the U.S. strategic Triad; meeting second-strike assured destruction criteria helped to answer "how much was enough" to deter Soviet aggression (*see* Assured Destruction).

During the mid-1970s, concerns began to emerge about the survivability of the land-based leg of the Triad as Soviet ballistic missile accuracy improved. Several strategists suggested that Soviet land-based missiles could in theory destroy U.S. land-based ICBMs and bombers, leaving only the submarine force to provide a secure second-strike capability. Given the limited accuracy of submarine-launched ballistic missiles, the United States would be presented with the choice of attacking Soviet cities, knowing the Soviets would respond in kind, or accepting defeat. Concerns about this "window of vulnerability" led to an increase in flexible counterforce targeting packages contained within the Single Integrated Operational Plan (SIOP, the nuclear war plan). The Trident D5 SLBM, the MX ICBM, which was to be deployed in rail-garrison, and the B-1B and B-2A strategic bombers were designed and built during the 1980s to improve both the survivability and second-strike counterforce capability of the U.S. strategic arsenal (*see* Counterforce Targeting).

Only the United States and Russia have maintained a traditional Triad of nuclear delivery systems. France has decommissioned its land-based ballistic missiles, and the People's Republic of China lacks a long-range bomber force and has barely managed to field one submarine capable of carrying nuclear-armed ballistic missiles.

—Andrew M. Dorman and James J. Wirtz

See also: Balance of Terror; Deterrence; Nuclear Posture Review; United States Nuclear Forces and Doctrine

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TRIDENT SLBMS/SSBNS

The U.S. Trident nuclear-powered submarine and its associated submarine-launched ballistic missiles (SLBMs) are the mainstay of the U.S. naval nuclear deterrent. In the 1970s, U.S. planners recognized that the SLBM system was the most survivable element in the "Triad" of strategic nuclear deterrent forces (land-based missiles and strategic bombers being the other two). Although the Poseidon ballistic missile was an improvement over the earlier Polaris SLBM, the nuclear-powered U.S. fleet ballistic submarine force itself was aging and would soon require a new submarine, particularly in view of an increased threat posed by Soviet antisubmarine warfare capabilities. Development began in 1971 for a new missile that was initially called the Trident C4 (later to become Trident I when Trident II was developed). (*See* Poseidon SLBMs/SSBNs; Submarines, Nuclear-Powered Ballistic Missile; United States Navy.)

Because they incorporated advanced technology in propellants, electronics, and other materials, the Trident C4 missiles had a much greater range than Poseidon, carrying a full payload to a range of 4,000 nautical miles and a reduced payload to even greater ranges. Like Poseidon, each Trident C4 missile was equipped with multiple independently targetable reentry vehicles (MIRVs), which gave it an ability to strike several targets simultaneously.

The Trident I missile was a three-stage, solid-propellant, inertially guided, submarine-launched fleet ballistic missile (FBM). It had a range a payload greater than the Poseidon missile and about double the range of the Poseidon C3, thus providing a significant increase in the operational area of the U.S. submarine fleet. The C4 was subsequently deployed in the new Trident submarine in addition to being backfitted into Poseidon submarines. The first tactical patrol in a backfitted Poseidon submarine took place in October 1979, and the first Trident submarine deployed in September 1982 from Bangor, Washington.

Starting in 1985, Poseidon C3 submarines were retired to offset the increasing numbers of Trident submarines. Poseidon submarines had to leave service to comply with the force size limits specified by the Strategic Arms Limitation Talks (SALT I) treaty and the unratified SALT II agreement. The remaining Poseidon submarines were eventually placed in a "stand-down" status, except for twelve submarines that were backfitted with the Trident C4 missile and saw continued service. The last Poseidon backfitted with Trident C4 was retired in 1994.

In October 1980, the U.S. Navy embarked on a three-year development program to build an enhanced SLBM designed to utilize the full volume available in the Trident SSBN's launch tube. The result was the Trident II (D5) missile. It was first flight-tested in January 1987 and subsequently deployed on board the USS *Tennessee* in March 1990. The Trident II missile is designed to serve as the primary U.S. strategic seaborne deterrent well into the twenty-first century. A three-stage, solid-propellant, inertially guided FBM, it is launched under water from Ohio-class (Trident) submarines, each of which has twenty-four launch tubes.

Trident D-5 missile launched from the nuclear-powered strategic missile submarine USS Tennessee, *February 1990. (PH2 Susan Marie Carl/Corbis)*

Like its predecessor, Trident II has a range of more than 4,000 nautical miles, but it has twice the payload (throw weight) capability of Trident I. The D5 missile is much larger than the C4 (44 feet in length and 83 inches in width versus 34 feet and 74 inches). It can carry either the Mark 4 or Mark 5 reentry bodies, each of which contains multiple independently targetable nuclear warheads.

The Trident submarine (Ohio 726 class) is the largest submarine in the U.S. Navy. It is 560 feet in length with a beam of 42 feet and weighs 18,700 tons. It has twenty-four launch tubes located midship and four bow torpedo tubes. It is capable of launching missiles under water while moving.

—*Guy Roberts*

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TRINITY SITE, NEW MEXICO

The Trinity Site is the location of the world's first atomic bomb test. Located in central New Mexico, the site is a National Monument within the confines of the White Sands Missile Range.

At 5:30 A.M. (Mountain War Time) on July 16, 1945, the United States tested a plutonium implosion device that yielded approximately 19 kilotons of explosive force. This test marked the culmination of the three-year-long Manhattan Project to design and develop an atomic bomb as part of the U.S. effort to win World War II. The bomb was designed and built at Los Alamos National Laboratory, and the plutonium came from the Hanford, Washington, nuclear reactors. The bomb tested was the same design that was used for the "Fat Man" bomb dropped three weeks later on Nagasaki, Japan. Scientists believed they had to test the implosion design, whereas the gun-type uranium design used in Hiroshima was calculated to have a high reliability of success and would not require testing.

After considering eight possible test sites in California, Colorado, New Mexico, and Texas, soldiers and engineers began preparing the Trinity Site in the Journada del Muerto (valley of death), an hour south of Albuquerque, in the fall of 1944. The site provided safety, security, isolation, and secrecy, while still within driving distance of Los Alamos.

Scientists assembled the high-explosive portion of the atomic bomb in the McDonald Ranch house, 2 miles from ground zero, on July 12. The plutonium core was inserted on July 13, and the completed weapon was carried to the top of a 100-foot tower at Trinity on July 14. Personnel were located at three observation points just 10,000 yards from ground zero.

The shock of the explosion broke windows 120 miles away. The military's public cover story was that an ammunition storage facility had accidentally exploded. The blast left a small depression on the desert floor some 100 yards wide, and the heat

Robert Oppenheimer and General Leslie Groves (center) examine the twisted wreckage of a hundred-foot tower that held the first nuclear weapon at Trinity Site, New Mexico, July 1945. (Corbis) melted the native sand into a green glass later named "trinitite."

The Trinity Site is open to the public on the first Saturday of April and October.

—Jeffrey A. Larsen

See also: Fat Man; Implosion Devices; Los Alamos National Laboratory; Manhattan Project; Nagasaki

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TRITIUM

Tritium is an unstable isotope of the element hydrogen that has one proton and two neutrons. On a geologic time scale, tritium has a short half-life and therefore is not found in nature. It has nuclear properties that are very useful in the nuclear industry and in facilitating fusion reactions, and its phosphorescent qualities make it a useful material as a radioactive tracer and in night and compass sights. In a nuclear detonation, tritium plays a part in both the primary and secondary stages of the weapon. Its name comes from the Greek word *tritos* (third).

In 1934, E. Rutherford, M. L. E. Oliphant, and P. Harteck bombarded deuterons with deuterons and produced the new isotope. Tritium is unstable and undergoes beta decay. It has a half-life of 12.32 years. Tritium is primarily used in fusion reactions with deuterium. Deuterium and tritium collisions have the highest probability of undergoing fusion in most conventional fusion systems. In a nuclear weapon's primary stage, a small quantity of deuterium and tritium gas is used to boost the yield through fusion reactions. Tritium is a product of fission reactions and is produced in an exothermic reaction from lithium by neutron bombardment. These are the primary production reactions that take place in the second stage of a thermonuclear weapon.

Tritium was produced for U.S. military uses at the Savannah River Plant in South Carolina. That facility is now closed. Nevertheless, tritium will remain important for civilian nuclear fusion systems and for commercial phosphorescence applications. In addition, because of its short half-life, tritium will continue to be needed by the United States to ensure that the primary stage of its nuclear weapons perform as expected. Along with deuterium, it will serve as the primary fuel for most magnetic and inertial confinement fusion systems.

—C. Ross Schmidtlein

See also: Deuterium; Half-Life; Isotopes; Neutrons; Thermonuclear Bomb

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TWO-MAN RULE

The two-man rule requires that a minimum of two authorized persons work on or near nuclear weapons or equipment in order to ensure the weapons' safety and security. These individuals must have technical knowledge and be in a position to detect incorrect or abnormal operations. Additionally, they must be familiar with all security and safety rules. During all contact with nuclear weapons or equipment, a two-man team must be present. Under no circumstances are U.S. nuclear weapons under the day-to-day custody of any one individual.

—Zach Becker

See also: Surety; United States Nuclear Forces and Doctrine

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U

U-2

The U-2 is a Lockheed-designed, high-flying aircraft with long-range reconnaissance capabilities. A glider-style aircraft, it is filled with advanced photographic and electronic intelligence-gathering equipment. The aerial photography equipment on board includes seven infrared cameras that can monitor radar networks and antiaircraft defenses. Its cameras are capable of photographing a strip of earth 125 miles wide and 3,000 miles long, with a resolution that can ostensibly allow a photo interpreter to read a newspaper headline 9 miles below the plane. Other instruments could detect evidence of nuclear tests. It flew at such high altitudes that it was thought to be undetectable and invulnerable throughout the 1950s.

During the Cold War, gaining detailed reconnaissance data about the U.S.S.R. was a paramount mission for the U.S. intelligence community. In response to that requirement, the U.S. Central Intelligence Agency engaged the Lockheed "Skunk Works," a secret aircraft-engineering organization headed by the legendary designer Kelly Johnson, to develop a spy plane that could evade Soviet air defenses and monitor Soviet conventional and nuclear force developments and deployments. These reconnaissance overflights of Russia continued from about 1956 until May 1960, when a U-2 was shot down over the U.S.S.R. Its pilot, Francis Gary Powers, parachuted from the damaged plane and was captured by the Soviets, causing much embarrassment to the Dwight D. Eisenhower administration. The incident occurred just weeks before a planned U.S.-Soviet summit in Paris with a promising agenda including disarmament, issues related to Berlin, and an improvement in relations between the nuclear powers. Powers spent ten years in a Soviet prison for spying.

During John F. Kennedy's administration, a U-2 was used to detect the placement of missiles in Cuba and to provide proof to the international community that the Soviets had decided to deploy nuclear-capable delivery systems just a few miles from America's shores. This deployment led to the Cuban missile crisis of 1962 (*see* Cuban Missile Crisis).

Updated versions of the U-2 are still used for intelligence gathering and for weather and atmospheric studies.

—Frannie Edwards

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UNDERGROUND TESTING

Since the 1940s, there have been more than 1,500 underground nuclear tests worldwide. More than half of these tests were conducted by the United States, and another one-third were conducted by the Soviet Union. The pace and importance of underground tests increased significantly after the 1963 signing of the Limited Test Ban Treaty, which prohibited tests in the atmosphere, water, and space. Over time, underground tests provided essentially the same useful information as had the earlier atmospheric tests. In the 1960s, a comprehensive test ban that would have included underground testing was considered but rejected for three reasons. First, the technology of the time could not guarantee verification of underground tests. Second, military officials and others argued that some continued testing was necessary to assure the safety and reliability of the U.S. nuclear arsenal. Third, many observers believed that testing was necessary to modernize weapons and keep up

Accidental release of radiation through a surface breach during the Baneberry underground nuclear test, Nevada Test Site, 1970. (Bettmann/Corbis)

with technological developments in other countries. Over time, public pressure has mounted to stop underground testing to save money, slow the arms race, and support nonproliferation efforts. Several countries have adopted moratoriums on testing, but the Comprehensive Test Ban Treaty opened for signature in 1996 has not gone into force.

During the Cold War, mutual distrust was a major factor holding back U.S.-Soviet arms control agreements. Clandestine underground tests remained possible because the Soviet Union refused to accept routine on-site inspections and technology could not accurately differentiate an underground test from a seismic event. Therefore, a comprehensive test ban was rejected. As Cold War tensions waned, the acceptance of on-site inspections increased. Seismic measuring technology was refined and new ways of measuring radioactive traces and infrasound were developed. Additionally, a global network of more than 300 monitoring stations was established. When India and Pakistan conducted nuclear tests in 1998, more than fifty stations reported data on the tests. Low-yield explosions remain difficult to monitor, but the U.S. government claims it can monitor Russian test site explosions down to very low yield.

Concerns about the reliability and modernization of weapons have lessened over time. Leading powers now have more than fifty years' experience with nuclear weapons and have collected data from the analysis of hundreds of tests. Additionally, beginning in the 1990s, the U.S. Stockpile Stewardship program has used advanced computer technology, lasers that can create miniature thermonuclear explosions, and other modeling techniques to assure the reliability of U.S. weapons. These technologies are used in modernizing and extending the life of existing warheads.

The first major limit on underground testing was the Threshold Test Ban Treaty, which prohibited tests having a yield exceeding 150 kilotons. The treaty was signed in 1974, but it was not ratified until 1990. In 1992, Congress passed legislation imposing a moratorium on U.S. testing. The United States has not conducted a test since September 1993. The 1996 Comprehensive Test Ban Treaty stopped all nuclear testing but was rejected by the U.S. Senate in 1999 (the United States, however, continues to abide by the treaty). President George W. Bush has suggested that the United States may end its moratorium in the future in order to maintain reliability or to test low-yield warheads that could be used against deeply buried bunkers.

—John W. Dietrich

See also: Comprehensive Test Ban Treaty; Limited Test Ban Treaty; Nuclear Test Ban; Threshold Test Ban Treaty

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UNILATERAL INITIATIVE

A unilateral initiative is a publicly announced decision or military action by one side in an adversarial relationship undertaken in the hope of reducing the level of distrust or saber-rattling by the two sides. The party making the first move usually anticipates that this show of trust will lead to reciprocal actions by the other side.

One of the most dramatic steps of this type occurred on September 27, 1991, when, in response to the dissipating Cold War, U.S. president George H. W. Bush announced several unilateral initiatives to reduce dramatically the size and nature of U.S. nuclear deployments worldwide and to enhance crisis stability. First, the United States withdrew its nuclear artillery shells and the nuclear warheads for its short-range ballistic missiles stationed in Europe and Korea to the United States. These warheads, along with those already stored in the United States, were then dismantled and destroyed. Second, the United States removed all tactical nuclear weapons, including nuclear-armed cruise missiles, from its surface ships and attack submarines. These weapons no longer are deployed on a routine basis by the U.S. Navy. Third, U.S. strategic bombers were dealerted and no longer kept in a ready launch status on a day-to-day basis. Their nuclear weapons were returned to storage areas instead of being kept loaded aboard an alert force of bombers. Fourth, the president canceled several U.S. nuclear force modernization programs, including the Peacekeeper intercontinental ballistic missile (ICBM) rail garrison system, the mobile elements of the small ICBM program (which was eventually canceled in its entirety), and a new nuclear-armed short-range attack missile (the SRAM-2). President Bush also announced the creation of a new U.S. Strategic Command to replace the Strategic Air Command. The purpose of the new organization was to improve the negative command and control of all U.S. strategic nuclear forces.

Although the president called on Soviet officials to undertake reciprocal initiatives, these U.S. actions were not predicated on Soviet willingness to adopt similar measures.

—James J. Wirtz

See also: Presidential Nuclear Initiative

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UNITED NATIONS SPECIAL COMMISSION ON IRAQ (UNSCOM)

The United Nations Special Commission on Iraq (UNSCOM) was formed in 1991 to assist the International Atomic Energy Agency (IAEA) in destroying, removing, or rendering harmless Iraq's nuclear

A UN inspector measuring the volume of nerve agent in a container at Muthanna, Iraq, November 1, 1991. (Rick Maiman/Corbis Sygma) facilities and ballistic missiles with a range greater than 150 kilometers. UNSCOM's mandate also included monitoring missile launchers, production, related major parts, and repair facilities. The aim was to ensure that Iraq would not rebuild its nuclear weapons program.

After losing the 1991 Gulf War, Iraq agreed, as a condition of surrender, to declare within fifteen days all of its weapons of mass destruction and the missiles to deliver them, and then to destroy them. This obligation was reinforced by UN Security Council Resolution 687, which formed UNSCOM on April 3, 1991, to provide for monitoring and verification of Iraq's compliance with these conditions of surrender. Iraq was not to use, develop, construct, or acquire weapons of mass destruction or associated delivery vehicles. Under the terms of the resolution, Iraq was barred from selling oil until UNSCOM verified the destruction of its prohibited weapons. UNSCOM's nuclear inspection teams were organized by the IAEA with the assistance and cooperation of members of the United Nations.

On April 18, 1991, Iraq provided an initial required declaration that mentioned fifty-three Al-Hussein and Scud long-range ballistic missiles. During its first inspections, September 21–30, 1991, IAEA inspectors found large amounts of documentation relating to Iraq's efforts to acquire nuclear weapons. Following these revelations, the IAEA, with the assistance and cooperation of the Special Commission, undertook fifty-three ballistic missile and thirty nuclear inspections. UNSCOM supervised the destruction of forty-eight operational long-range missiles, fourteen conventional missile warheads, six operational mobile launchers, twenty-eight operational fixed launch pads, thirty-two fixed launch pads (that were under construction), thirty missile chemical warheads, and other missile support equipment and materials. It also supervised the destruction of a variety of assembled and nonassembled "super-gun" components. UNSCOM was instrumental in assisting the November 1995 interception by Jordan of a large shipment of high-grade missile components destined for Iraq. The commission's experts also participated in negotiations with the Russian Federation regarding the sale of the nuclear fuel removed from Iraq and reprocessed in the Russian Federation. The disclosures of Iraq's nuclear program led to efforts to strengthen the IAEA safeguard agreements.

UNSCOM began its first missile inspection on June 30, 1991. Iraq consistently tried to evade its responsibilities. Following Iraqi insistence, UNSCOM withdrew all its staff from Iraq on December 16, 1998.

The UN Security Council adopted Resolution 1284 on December 17, 1999, replacing UNSCOM with the United Nations Monitoring Verification and Inspection Commission (UNMOVIC).

—*Glen M. Segell*

See also: Iraqi Nuclear Forces and Doctrine

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UNITED STATES AIR FORCE

The U.S. Air Force was established as a separate service by the National Security Act of 1947. Following the nuclear bombing of Hiroshima and Nagasaki by Army Air Force aircraft at the end of World War II, the United States needed to develop new systems for managing and operating its growing nuclear arsenal. In this context, the newly independent air force took the lead role in deploying and preparing to deliver nuclear weapons. Strategic Air Command (SAC), with its postwar bomber force and deliverable nuclear weapons, was the cornerstone of early U.S. deterrence strategy. Throughout the Cold War, research and development of nuclear weapons continued while the United States created a "Triad" of nuclear forces consisting of nuclear bombers, intercontinental ballistic missiles (ICBMs), and the navy's submarine-launched ballistic missiles (SLBMs). Each leg of the Triad had advantages and disadvantages that were balanced by the other two. The U.S. Air Force, through SAC, controlled two legs of the Triad: bombers and ICBMs.

The air force first relied on propeller-driven B-29 and B-36 bombers, eventually replacing them with B-47 and B-52 jet bombers armed with smaller and more powerful nuclear weapons. In the late 1950s, it began adding ICBMs to its inventory of nuclear delivery systems. Atlas, Titan, and Minuteman missile systems created a new industry and provided long-term deterrence capability. Throughout the 1970s

Two F-16 Fighting Falcons preparing to refuel from a KC-135E Stratotanker over San Francisco during an Operation Noble Eagle patrol, March 2004. (U.S. Air Force photo by Master Sgt. Lance Cheung)

and 1980s, the air force continued to advance and expand space technologies. These space-based systems enhanced nuclear targeting, early warning systems, and enhanced arms control and treaty verification. A reorganization of commands in the 1990s created the U.S. Strategic Command (USSTRATCOM). This unified command replaced SAC, establishing a single commander (alternating between four-star air force and navy flag officers) for the planning, targeting, and wartime employment of strategic nuclear forces. Day-to-day training and maintenance of their respective systems remains the responsibility of each service.

The mission of the U.S. Air Force is to defend the United States and protect its interests through aerospace power. It can deliver "tactical" nuclear weapons using shorter-range "dual-capable" aircraft such as the A-10, F-15E, and F-16, but the strategic bomber and ICBM remain the air force's key global delivery platforms for nuclear weapons. U.S. Air Force bombers such as the B-52 or stealthy B-2 may be used to carry nuclear gravity bombs or nuclear-armed cruise missiles. The bombers are maintained at various stages of alert, depending on the international threat environment. ICBMs, such as the Minuteman and Peacekeeper, retain the ability to hold time-urgent enemy targets at risk on a day-to-day basis. Their ground-based, hardened launch facilities afford a high degree of survivability if attacked, and their high accuracy gives them the ability to destroy an opponent's hardened targets. Unlike the bombers, however, once an ICBM is launched, it cannot be recalled.

The 2001 Nuclear Posture Review (NPR) describes a "new Triad." The new Triad concept restructures U.S. strategic forces to include legs for missile defenses, a "responsive infrastructure," and a strategic deterrent, which integrates both nonnuclear and nuclear strike capabilities.

—*Chris Craige*

See also: Strategic Air Command and Strategic Command; Triad; United States Nuclear Forces and Doctrine

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UNITED STATES ARMY

The U.S. Army is the world's leading combined-arms land combat force. Its mission is to fight and win the nation's wars by providing prompt, sustained land dominance across the full spectrum of military operations and spectrum of conflict. Title 10 and Title 32 of the United States Code task the army with organizing, training, and equipping forces to conduct missions as directed by the president, secretary of defense, and regional combatant commanders. The army is composed of both active and reserve components.

A variety of army units provide a broad spectrum of operations, from peacekeeping and humanitarian assistance to full-scale war. The army has heavy armored and mechanized forces as well as light, airborne, air assault, and special operating forces. The army's heavy forces are composed of tanks, armored infantry carriers, and other specialized armored vehicles. They have significant firepower and rapid battlefield mobility provided by such vehicles as the M1 Abrams tank, the M2 Bradley infantry-fighting vehicle, the M109 Paladin howitzer, and the AH-64 attack helicopter. This heavy force, however, requires extensive logistics support and must be transported by ship to the battlefield or pre-positioned nearby. The airborne and air assault forces are lightly equipped; most equipment is carried into battle in these units by light vehicles or the soldiers themselves. Light forces can be transported by air to the battlefield in hours. Once there, they can move by helicopter, truck, or on foot. Special operating forces provide a variety of skills, including unconventional warfare, direct action, and reconnaissance. The light forces have limited firepower.

The army's primary combat organization is the division. A division has approximately 20,000 soldiers organized into three brigades as well as artillery, engineer, aviation, supply, and medical units. The U.S. Army currently contains ten active-duty divisions stationed and deployed around the world.

During the Cold War, the Army had a large nuclear mission, providing intermediate-range ballistic missiles, short-range battlefield missiles, and artillery-fired atomic projectiles (atomic artillery) to its forward-deployed forces and allies, particularly in Europe and Korea. This mission was eliminated after the Cold War ended in the 1990s. Today, the army retains a residual planning capability to conduct nuclear operations and to operate on a nuclear battlefield.

—Bret Kinman

See also: United States Nuclear Forces and Doctrine

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UNITED STATES NAVY

The U.S. Navy constitutes an essential instrument of U.S. warfighting doctrine and strategic deterrence. It provides the United States with the ability to stage strategic nuclear weapons from platforms that are highly mobile and difficult to detect. The credibility of the U.S. nuclear deterrent depends on this ability to retaliate even if it comes under an all-out nuclear attack.

The most survivable component of the U.S. nuclear arsenal resides in its eighteen Ohio-class ballistic missile submarines (SSBNs, for "ship submersible ballistic nuclear"). The Ohios, each carrying twenty-four Trident II D5 missiles, collectively represent roughly 50 percent of the total U.S. strategic warheads. Although the missiles have no preset targets when the submarine goes on patrol, the SSBNs are capable of rapidly targeting their missiles should the need arise, using secure and constant at-sea communications links (*see* Submarines, Nuclear-Powered Ballistic Missile; Trident SLBMs/SSBNs).

In addition to the SSBNs, U.S. Navy attack submarines are able to conduct nuclear strikes by using nuclear-capable versions of the Tomahawk Land Attack Missile (TLAM). The Tomahawk Block II Nuclear variant (TLAM-N) carries the W80 nuclear warhead and can travel at subsonic speeds at a low altitude for up to 2,500 kilometers. In the aftermath of President George W. Bush's 1991 announcement that nuclear weapons would no longer be deployed on a routine basis on U.S. Navy warships, TLAM-N is kept in storage and has not been deployed at sea.

The U.S. Navy will also provide a portion of the United States' layered theater missile defense (TMD) capability by 2005. TMD involves protecting a geographic area from attack by theater missiles

The USS Kitty Hawk *Battle Group and ships from Japan's Maritime Self Defense Force conducting exercises, 2003. (U.S. Navy photo by Photographer's Mate 3rd Class Lee McCaskill)*

and aircraft. The navy has been able to achieve upper-tier defense capabilities with the Aegis Ballistic Missile Defense (BMD) program (formerly called the Navy Theater Wide system), which uses upgraded versions of the Aegis radar and Standard missile defense systems. BMD will use Standard missiles, modified for intercepts outside the atmosphere, in tandem with the Aegis combat system (*see* Theater Missile Defense).

Since the end of the Cold War, the U.S. Navy's role has expanded to include direct participation in covert operations. Ballistic missile submarines still constitute a major aspect of the U.S. strategic deterrent, but some SSBNs are being transformed into submarines that are better suited to fight the war on terror. Four Ohio-class submarines that were previously scheduled for inactivation are being converted to guided missile submarines (SSGNs, for "ship submersible guided nuclear").

Although the primary role of some submarines may change, the main objectives of the U.S. Navy will remain the same. SSBNs are highly mobile, difficult to detect, and highly capable of delivering many nuclear warheads quickly and accurately. As long as this capability remains credible, the U.S. strategic deterrent will remain secure.

—*Abe Denmark*

See also: United States Nuclear Forces and Doctrine

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UNITED STATES NUCLEAR FORCES AND DOCTRINE

The world entered the age of nuclear combat when in August 1945 American B-29s dropped atomic bombs on Hiroshima and Nagasaki, shocking Japan into surrender. The secret unit formed to deliver the bomb was equipped with aircraft modified to accommodate the Volkswagen-sized weapons. This early atomic bomb was still essentially a laboratory device that required a team of scientists to assemble and arm and that, once assembled, had to be used (or disassembled) before its batteries ran down.

Early U.S. nuclear doctrine was embedded in the broader strategic bombing doctrine that was refined in combat during the war—attack military targets located in urban areas using precision bombing wherever possible. "Precision" was, of course, relative to the technology of the times and, especially in the Japanese campaign, was abandoned in favor of broad-area fire bombing because of operational considerations. Scholars of military history now know that had the Japanese not surrendered after Nagasaki, the next several nuclear weapons probably would have been used tactically against massed Japanese forces opposing a U.S. land-air-sea invasion of Japan as U.S. fire-bombing raids destroyed remaining Japanese cities and a naval blockade isolated the Japanese mainland. Then, as now, technology, policy, and the circumstances of battle interacted to shape doctrine.

U.S. nuclear forces and doctrine developed slowly after 1945 owing to budget constraints, the primitive nature of nuclear weapons at that time, uncertainties about U.S. global strategy and the type of military forces needed to support that strategy, and the soon-to-commence negotiations in the newly formed United Nations to try to control and perhaps even ban nuclear weapons. From the beginning, nuclear weapons were placed by U.S. authorities in a special category. Explicit presidential authorization was required for developing, testing, deploying, and using atomic bombs. This special status was recognized in early presidential directives such as National Security Council Document 30 (NSC-30), adopted in 1948.

The Growth of Nuclear Forces

As the Cold War unfolded and the imperative of deterring Soviet aggression became paramount, nuclear weapons moved to the heart of U.S. military strategy. U.S. nuclear forces and doctrine evolved accordingly. With the advent of the North Atlantic Treaty and the Soviet test of its first nuclear bomb in 1949, the U.S. deterrent strategy became more complicated and new target categories were added to the strategic air offensive annexes of its contingency war plans. In the late 1940s, strategic air plans continued to rely heavily on conventional as well as nuclear weapons.

In 1950, before the outbreak of the Korean War, President Harry S. Truman approved a major expansion of the nuclear stockpile. He also approved development of the thermonuclear (hydrogen) bomb. NSC-68, one of the first major reviews of U.S. national security strategy, was launched in response to the H-bomb decision. In 1950, the U.S. nuclear stockpile numbered some 300 bombs that still were large devices close to the designs of the original nuclear weapons. By the end of the decade, the robust production and development program launched by President Truman had produced a stockpile of more than 12,000 nuclear weapons (and a number of new, more sophisticated designs) deployed not only on large strategic bombers but with U.S. tactical air, sea, and land forces.

The Korean War marked a major turning point for the United States. It confirmed the priorities and tensions of a Europe-first grand strategy that continued until the end of the Cold War. It demonstrated the difficulty of using the nuclear shadow to affect conflicts fought on the margins of the major East-West confrontation. And, notwithstanding the desperate nature of the Korean crisis, the fact that the United States did not use nuclear weapons reinforced the evolving norm that nuclear weapons were tools of last resort, reserved for the most strategically threatening occasions. During the Korean War era, the world also entered the thermonuclear age. There was now no apparent limit to the destructiveness that could be packaged in a single thermonuclear device (*see* Thermonuclear Bomb).

When President Dwight D. Eisenhower took office in January 1953, his highest priorities were to end the Korean War, to anchor the United States to the North Atlantic Treaty Organization (NATO), and to translate what he and his advisers saw as an inchoate containment and deterrence strategy into a coherent grand strategy attuned to the needs of a long, inconclusive struggle conducted in the shadow of the bomb's ability to threaten apocalyptic destruction. U.S. nuclear forces, still heavily centered around the long-range bombers of Strategic Air Command, were at the heart of this endeavor. NSC-162/2, adopted in late 1953, offered a strategy that linked nuclear weapons and deterrence to the long-range mission of containing the Soviet Union.

During the 1950s, the East-West nuclear arms race accelerated. The United States developed a wide range of nuclear weapons deployed on a number of strategic and tactical platforms. Nuclear doctrine evolved to reflect this capability, albeit with final authority for using nuclear weapons reserved to the president or, in the event of his incapacitation, his designated successors (called the National Command Authority). Although Congress exercised indirect influence on the nuclear programs through its budgeting authority, fundamental decisions on U.S. doctrine and on the size, composition, deployment, and use of nuclear forces remained with the executive branch. Also during the 1950s, the imperative of being able to survive a surprise nuclear attack and respond with a substantial "second strike" became a key element of U.S. nuclear doctrine (*see* Arms Race; Deterrence; Second Strike).

Although missile programs had begun both in the United States and in Russia during World War II, and had become more important with the advent of the German V-1 and V-2 systems, missiles developed slowly during the 1950s. Thus U.S. strategic offensive and defensive nuclear doctrine remained focused on bomber aircraft. The United States constructed a large air defense network during these years and could explore preemptive options for striking Soviet nuclear bomber bases in the face of an imminent Soviet attack. The Soviets progressed quickly with their missile programs, however, and whatever prospect there had been of entertaining the idea of a preemptive nuclear first strike in U.S. strategic doctrine faded (*see* Preemptive Attack).

The shock of Sputnik—the first artificial Earth-orbiting satellite—on the United States and its allies cannot be overstated. It contributed immediately to the development of a NATO nuclear stockpile with nuclear sharing arrangements for otherwise nonnuclear NATO partners and accelerated work on missiles. When President Eisenhower turned over the reins of government to President John F. Kennedy in 1961, the basic structure of the Cold War U.S. nuclear posture and a number of its supporting processes were in place. Strategic nuclear forces consisted of a "Triad" of long-range bombers, intercontinental ballistic missiles (ICBMs), and submarine-launched ballistic missiles (SLBMs). The intercontinental cruise missile, the Snark, also was operational, though only for a short time, creating a "Quadrad" of systems. Tactical nuclear weapons were deployed with a wide range of forces. A large design and production complex was in place to refurbish the U.S. stockpile, and a large industrial complex supported production and development of new generations of strategic delivery systems. Command and control (C2) and intelligence, surveillance, and reconnaissance (ISR) systems likewise were under continual development and refinement. The Joint Strategic Target Planning Staff (JSTPS) had been created in Omaha, Nebraska, to develop the Single Integrated Operational Plan (SIOP), and the U.S. strategic war plan was beginning to be coordinated with NATO nuclear planning (*see* Cold War; Single Integrated Operational Plan; Strategic Forces; Tactical Nuclear Weapons; Triad).

Flexible Response and Arms Control

During the Kennedy and Lyndon B. Johnson administrations, the United States moved from a doctrine of "massive retaliation" to one of "flexible response." In fact, out of the public eye, this process already was under way prior to Kennedy's inauguration. By 1961, planning for the strategic air offensive—now entirely nuclear—had become an enormously complex affair. The new Kennedy administration moved to try to create more strategic nuclear options for the president in the event of an emergency. It also sought to recentralize NATO nuclear decision-making in U.S. hands and to seek means of delaying the need to cross the nuclear threshold. Notwithstanding the public manifestations of the Kennedy strategy—for example, Secretary of Defense Robert McNamara's Ann Arbor speech in 1962, where he tried to entice the Soviets to a counterforce doctrine, the "new" NATO strategy unveiled in MC-14/3 in 1967—the United States and its allies remained heavily dependent upon early resort to nuclear weapons in any major military confrontation with the Soviet Union. Nuclear options continued to be quietly explored for noncentral confrontations such as Vietnam, and to be rejected (*see* Counterforce Targeting; Flexible Response; Massive Retaliation).

During the early 1960s, U.S. nuclear doctrine and force planning began to interact more deeply with arms control theories that stressed the need to stabilize the nuclear confrontation. After the Cuban missile crisis in late 1962, the Americans and their British allies undertook a major initiative to reinvigorate the on-again, off-again nuclear testing talks that had begun in the 1950s, resulting in the Limited Test Ban Treaty in 1963. U.S. authorities also were exploring ways of beginning strategic arms control talks. Moreover, a newly forming nonproliferation agenda became serious after the Chinese detonated their first nuclear weapon in 1964, and the prospect of major deployments not only of missile forces but also of antiballistic missile systems emerged. In 1965, President Johnson committed the prestige of his presidency to seeking a Nuclear Nonproliferation Treaty (NPT), and his administration quietly began reviewing ways to initiate strategic arms talks (something derailed by the Soviet invasion of Czechoslovakia in 1968) when the NPT was opened for signature (*see* Arms Control; Limited Test Ban Treaty; Nuclear Nonproliferation Treaty; Nuclear Test Ban).

The Richard M. Nixon administration took office in 1969 at the height of the Vietnam War. The backlash from this war spilled over into the strategic weapons debate, leading indirectly to the early demise of America's first operational antiballistic missile (ABM) system. Meanwhile, President Nixon and his national security team adjusted to the pace of the missile race. In 1965, the Soviets had slightly more than 200 ICBMs and fewer than 100 SLBMs. By 1969, Soviet missile forces were growing at the rate of 200–300 missiles annually and were projected to equal if not surpass U.S. numbers by 1971.

In this context, the new Nixon administration commenced the Strategic Arms Limitation Talks (SALT), which resulted in 1972 in the Anti-Ballistic Missile (ABM) Treaty and the interim agreement on offensive arms. The ABM Treaty in effect codified the doctrine of assured destruction that had been embraced by the Kennedy administration after the short-lived effort to entice the Soviets to adopt a purely counterforce strategy, leading to a situation of mutual assured destruction (MAD). Also in 1972, the Nixon administration began a review of its nuclear policy that resulted in 1974 in National Security Decision Memorandum (NSDM) 242—a policy that reprioritized the targets to be held at risk with strategic nuclear weapons toward industrial targets, called for even more options in the nuclear war plan, created a secure reserve force, and sought ways to further refine escalation control should deterrence fail. A document called the Nuclear Weapons Employment Policy (NUWEP), first issued in 1974, conveyed the new guidance, and on this basis the JSTPS restructured the SIOP into major attack options (MAOs), selective attack options (SAOs), and limited attack options (LAOs). U.S. strategic bombing doctrine during and after World War II had centered on a number of target sets that now were formalized into the primary categories of military forces (subdivided into nuclear and nonnuclear forces), war-supporting economic and other industrial targets, and leadership and command and control (*see* Assured Destruction; Mutual Assured Destruction; Strategic Arms Limitation Talks).

Concerned Allies

NATO nuclear strategy also continued to evolve and interact with U.S. nuclear strategy. The allies were relieved that the United States had successfully excluded "forward-based" U.S. nuclear forces from SALT negotiations. Faced with the prospect of further reductions in SALT II, which began in 1972, however, many allies worried openly about the credibility of the U.S. nuclear guarantee. As the Soviets began replacing their first-generation intermediate-range ballistic missiles targeted on Europe with the SS-20, which incorporated the new multiple independently targetable reentry vehicle (MIRV) technology, the European concerns multiplied. Congressional pressure led the Gerald Ford administration to provide the most public explanation of the alliance's nuclear policy and strategy to date, and at a meeting of the NATO Nuclear Planning Group (NPG) in early 1976, Secretary of Defense Donald Rumsfeld convinced the allies of the need to modernize the NATO nuclear stockpile to keep pace with evolving policy and doctrine.

Nuclear Testing

In 1974, India conducted its first nuclear test, joining the United States, the Soviet Union, Britain, France, and China as a country that had explosively tested nuclear devices. With progress in SALT moving slowly, the Nixon and Ford administrations shifted attention to nuclear testing, pursuing new nuclear testing bans. When President Jimmy Carter took office in 1977, he completed the SALT II talks, but—this time owing to the Soviet invasion of Afghanistan in 1979—placed on hold the Senate's deliberation on the treaty. Also by 1977, the United States was developing the MX and Trident missile systems, a wide range of new cruise missiles, and the B-1 bomber. Out of the public eye, the United States also began covertly exploring stealth technology, a fact that the public and many congressmen were unaware of when the Carter administration took its controversial decision to cancel further procurement of the B-1 bomber.

The Countervailing Strategy

After conducting an initial review of national security strategy, the Carter administration began a concentrated study on nuclear targeting policy led by Leon Sloss. This study concluded that the United States needed to adjust its nuclear deterrent strategy and doctrine to reflect how the Soviets approached war planning and what they truly valued, that is, the United States should place greater emphasis on the complex problem of holding at risk Soviet military forces and the Soviet military command structure. These studies formed the basis for Presidential Directive (PD) 53, which reinvigorated programs for ensuring that American strategic command and control could survive a nuclear attack and continue to function, and for PD-59—a new nuclear policy that, among other things, shifted targeting priorities away from industries and the concept of impeding industrial recovery and provided for a more robust secure reserve force. PD-59 was unveiled publicly by Secretary of Defense Harold Brown and identified for public diplomacy purposes as the "countervailing" strategy. The concept, again as explained publicly, was to seek to ascertain the war aims of the enemy and to then hold at risk assets critical to the success of those aims, thus denying victory to the enemy. The concept of punishment did not disappear as an element of deterrence, but at least for the moment, the concept of denial gained a more prominent role in U.S. nuclear doctrine.

In the midst of the Iranian hostage crisis, Ronald Reagan campaigned for president in 1980. Although highly critical of formal arms control, the newly elected Reagan administration bowed to European sentiment when it resumed theater nuclear force talks in 1981 under the new name of intermediate nuclear forces (INF). In 1981, the new administration conducted its own nuclear targeting review and basically reaffirmed PD-59 guidance. At the same time, the administration was conducting a Damage Criteria Study (DCS) to facilitate translating nuclear targeting objectives into a more coherent target and attack criteria framework. In late 1981, the Reagan White House issued National Security Decision Directive (NSDD) 13, which superseded but did not significantly change PD-59. In 1982, President Reagan also approved the commencement of negotiations for a Strategic Arms Reduction Treaty (START). START, unlike SALT, sought actual reductions in nuclear weapons. By this time, the Reagan administration had set in motion a major rearmament program to challenge the Soviets across the board. In 1983, in announcing the Strategic Defense Initiative, the president increased this pressure (*see* Strategic Arms Reduction Treaty; Strategic Defense Initiative).

The End of the Cold War

After World War II, U.S. nuclear doctrine and forces had evolved as part of a broader national security strategy centered around the concept of containing and deterring the Soviet Union until Soviet domestic change might make possible a dramatically different strategy. Few sensed in the early 1980s that this kind of change was on the horizon. The United States built up its military forces and, in 1986, finally abandoned SALT II (when the continued conversion of B-52 bombers to carry air-launched cruise missiles [ALCMs] exceeded the SALT II limits). Other arms control talks proceeded slowly. Ailing Soviet president Leonid Brezhnev, who had exercised power since replacing Nikita Khrushchev in 1964, finally died in 1982, to be succeeded by Yuri Andropov (who, also ill, died in 1984) and then by Konstantin Chernenko (who died in 1985). The Soviets undertook the bold step of promoting a young, dynamic politician—Mikhail Gorbachev—to the center of their decision-making apparatus. In the face of the failing Soviet economy and the pressures of the Reagan rearmament plan, Gorbachev undertook a number of initiatives, some of which centered on arms control and some of which centered on domestic political reform, that—within a few short years—resulted in the unexpected end of the Cold War and the equally unexpected collapse of the Soviet empire. Along the way, NATO displayed solidarity in proceeding with the deployment of new theater nuclear systems—the American Pershing II intermediate-range ballistic missile (IRBM) and the ground-launched cruise missile (GLCM)—notwithstanding a massive Soviet diplomatic campaign to mobilize European opposition.

The Soviets broke off arms control talks after the NATO deployments, but (with Gorbachev now in power) a way was found to resume talks. In December 1987, Reagan and Gorbachev signed the INF Treaty banning all U.S. and Soviet land-based ballistic missiles and GLCMs in the 500- to 5,500-kilometer range. This was in effect the first nuclear disarmament treaty because it required the destruction and future prohibition of an entire range of nuclear delivery systems. The Threshold Test Ban Treaty and the Peaceful Nuclear Explosions Treaty of the 1970s, which had never entered into force because of verification concerns, now acquired verification protocols that allowed them to take effect (*see* Intermediate-Range Nuclear Forces Treaty).

President George H. W. Bush, the forty-first president of the United States and father of the future forty-third president, came to office as the Cold War was ending. He and his national security team presided over the reunification of a German state that retained membership in NATO, the largely peaceful withdrawal of Soviet forces from their external empire, and—in the face of attempted coups—the largely peaceful collapse of communism in the Soviet Union. While this was going on, the first Gulf War also began to reorient U.S. nuclear doctrine toward an existing but now more pressing threat—the proliferation of weapons of mass destruction (WMD) to regional states such as Iraq, North Korea, and Iran.

New Roles for Nuclear Weapons

By the early 1990s, the United States was reorienting its nuclear forces and beginning to explore how to redirect its nuclear doctrine in the face of the new geopolitical circumstances. The process was messy, with a number of forces intervening. For instance, the new environmental awareness that had developed since the 1940s foreshadowed the closing of the plutonium production facilities at Rocky Flats in Colorado in 1992 (production already had been suspended). In the early 1990s, the United States pursued what to many appeared to be a largely piecemeal nuclear agenda to adjust to the new security environment. START I negotiations proceeded to closure in 1991, but the collapse of the Soviet Union delayed its entry into force while the issue of nuclear succession was resolved. Eventually, Ukraine, Belarus, and Kazakhstan agreed to give up nuclear weapons and to join the NPT as non–nuclear weapons states. The United States undertook unilateral actions to further stabilize the dangerous transition period, hoping to assure Moscow and to elicit stabilizing actions from its former adversary. U.S. strategic bombers were taken off alert, the production of a number of nuclear systems was terminated, Strategic Air Command was dissolved and its forces transferred to several U.S. Air Force commands, and the Joint Strategic Planning Staff was replaced with a new unified command—U.S. Strategic Command. And, as an initiative that began in Congress, the United States entered a nuclear testing moratorium in 1992 while it pursued a formal Comprehensive Test Ban Treaty (*see* Comprehensive Test Ban Treaty).

President William Clinton took office in 1993 in the midst of these changes. Later that year, the Defense Department announced the counterproliferation initiative to complement traditional U.S. nonproliferation strategy. The new administration also shifted emphasis to theater missile defense while essentially refocusing the national missile defense effort as a research and development effort. Congressional politics intervened, however, as the Republicans took control of both chambers of Congress in the 1994 election, and national missile defense again became an issue. In 1994, the first Nuclear Posture Review (NPR) was conducted. U.S. nuclear forces and doctrine remained largely intact as a result of this review, hedging against the uncertainties of the Russian transition to democracy—a process that also made progress in strategic arms control slow and difficult. In 1993, North Korea created a crisis when it announced its intention to withdraw from the NPT, something that was averted (at least temporarily) by the 1994 Agreed Framework arrangement. In 1995, at a critical review and extension conference, the parties agreed that the NPT would remain in force indefinitely (*see* Missile Defense; North Korean Nuclear Weapons Program; Theater Missile Defense).

The United States was the first to sign the recently completed CTBT in September 1996. On the road to this agreement, the Clinton administration had decided it would support a truly “zero-yield” outcome and, as part of the bargain in the arrangement, began constructing a Stockpile Stewardship Program (SSP) to explore how the safety and reliability of the U.S. nuclear stockpile might be retained in the absence of nuclear testing. Despite the rejection of the CTBT by the Senate in 1999, the United States continues to observe a self-imposed nuclear testing moratorium (*see* Stockpile Stewardship Program).

In 1998, the nuclear landscape shifted as India and Pakistan both openly tested nuclear weapons and proclaimed themselves to be nuclear weapons states. Despite being defeated in the first Gulf War in

1990–1991, Saddam Hussein was still in power in Iraq and was thought to again be seeking weapons of mass destruction—something that escalated in importance when he ejected the United Nations inspectors from Iraq in the late 1990s. The George W. Bush administration fought a second Gulf War in 2003 to oust Hussein from power and to eliminate the threat that his regime would obtain nuclear, chemical, or biological weapons (*see* Indian Nuclear Weapons Program; Iraqi Nuclear Forces and Doctrine; Pakistani Nuclear Forces).

President George W. Bush won the 2000 elections and, notwithstanding a narrow mandate, set out to transform U.S. military forces. One of the early priorities of the new Bush administration was to terminate the ABM Treaty in order to allow the deployment of ballistic missile defenses aimed at "rogue" states such as North Korea. A Quadrennial Defense Review (QDR) and Nuclear Posture Review (NPR) were under way when the terrorist attacks of September 11, 2001, took place—an event that was as important as Pearl Harbor had been in 1941 in shifting U.S. national security strategy. The new NPR announced in January 2002 took account of the importance of the supporting infrastructure and of strategic defenses as part of the overall U.S. deterrent, moved unilaterally to reduce U.S. strategic nuclear forces to a level of 1,700–2,200 operationally deployed warheads by 2012, and continued the emphasis in seeking new conventional means to hold at risk targets once considered possible targets for nuclear weapons (*see* Nuclear Posture Review; Quadrennial Defense Review).

Looking Ahead

The tensions and promises of the new NPR, the evolving strategic relationship with Russia (reflected in the 2002 Strategic Offensive Reduction Treaty—SORT—which codified the unilaterally announced reductions), the uncertainties associated with Chinese ambitions and programs—these issues continue to underlie policy debates. But the epicenter of the debate has shifted from the traditional concerns of the Cold War to the new threat posed by regional powers with aggressive intentions seeking WMD and to the daunting fear that terrorists such as Osama bin Laden might acquire and use such weapons and might be undeterrable. The 2003 war in Iraq addressed these concerns. The challenges posed by North Korea (which now has withdrawn from the NPT), by Iran, by other rogues, by the Indian and Pakistani nuclear programs, by the Arab-Israeli confrontation and the underlying question of WMD—these all are on the table.

U.S. nuclear doctrine has come full circle since the 1940s as the United States adjusts its nuclear forces and doctrine to the new age. The U.S. preference for precision bombing, pursued with great difficulty in World War II with the secret Norden bombsight after half a century of investment and technological development, has evolved into a capability that allows the United States to rely less and less on nuclear weapons. The fear that the proliferation of nuclear weapons could mortally threaten the United States, a fear that helped inspire the 1946 effort to control or ban nuclear weapons through the Baruch Plan, remains, though it has shifted from great-power confrontation to the rogues and terrorists (*see* Baruch Plan).

Since the United States dropped the atomic bombs on Hiroshima and Nagasaki, nuclear weapons have not been used in combat. They have become powerful political instruments instead of warfighting weapons. But that does not mean they never will be used again, nor (as the Bush administration so clearly recognized) that deterrence in the future will resemble deterrence in the past. U.S. nuclear forces and doctrine have evolved enormously and continue to evolve in a world where nuclear weapons remain a currency that must be managed and perhaps can be controlled, but also a world that cannot be returned to some pre–nuclear age, where harnessing the power of the atom for military and civilian purposes was at best a dream that would be realized in a distant future.

—*Michael Wheeler*

See also: Strategic Air Command and Strategic Command; Strategic Defenses; Submarine-Launched Ballistic Missiles (SLBMs); United States Air Force; United States Army; United States Navy

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URANIUM

Uranium is the heaviest naturally occurring chemical element. It is a dense, heavy metal that contains 92 protons and, in its natural state, is weakly radioactive. Refined uranium is a silvery-white metal that is toxic if inhaled or ingested in other than very small quantities.

Uranium is found throughout the world in minute quantities in most plants, animals, water, soil and rock. It is about as abundant as tin or tungsten in nature. Major sources of recoverable uranium can be found in uranium deposits. These deposits are mined throughout the world but mostly in Canada, Australia, Kazakhstan, Niger, South Africa, Namibia, Brazil, Russia, the United States, and Uzbekistan. Canada, the world's greatest uranium producer, mines approximately 30 percent of the world's supply, while Australia mines about 20 percent.

Enriched uranium is used as fuel for nuclear reactors and weapons. Depleted uranium, which contains less of the isotope uranium 235 than in nature (generally less than 0.2 percent), serves many military purposes, including use as armor-piercing ammunition, protective shielding, and wing components for helicopters and counterweights in airplanes. Depleted uranium also has industrial uses, including use as reinforcement in building materials such as concrete.

When bombarded with neutrons, uranium produces manmade isotopes such as plutonium, which is another type of fuel used in nuclear reactors and weapons.

History and Background

A German chemist named Martin Heinrich Klaproth is credited with the discovery of uranium in 1789. Klaproth actually discovered uranium oxide, which he believed to be pure uranium, in the mineral pitchblende. Pitchblende is a naturally occurring mineral that is a mix of uranium oxides. He named the new element after the recently discovered planet Uranus.

In 1841, French chemist Eugene-Melchoir Peligot isolated pure uranium metal. In 1896, French physicist Antoine Henri Becquerel discovered that uranium was radioactive. While Becquerel was investigating the fluorescence of uranium salt, he inadvertently discovered radioactivity. In 1903, he won the Nobel Prize in Physics for his discovery of spontaneous radiation.

Natural uranium was used in the first experimental nuclear reactor, designed and built on December 2, 1942, by Italian physicist Enrico Fermi at Stagg Field Stadium in Chicago. With this reactor, known as Fermi's Pile, Fermi achieved the first nuclear chain reaction. The "pile" consisted of approximately 40 tons of uranium oxide and 6 tons of uranium metal intermingled with 385 tons of pure graphite that moderated, or slowed, neutrons to limit thermal energies produced by the nuclear chain reaction.

Approximately 60 kilograms of highly enriched uranium were used to build "Little Boy," the first nuclear weapon. The Little Boy bomb was dropped by the United States on Hiroshima, Japan, on August 6, 1945, and yielded the equivalent energy of approximately 15,000 tons of TNT. Construction of the Little Boy weapon exhausted nearly the entire stockpile of highly enriched uranium in the United States at the time.

Uranium also is used to produce the manmade element plutonium. Approximately 200 tons of uranium metal was bombarded with neutrons in the first "breeder" reactor at the B Reactor at Hanford, Washington, to produce quantities of plutonium for nuclear weapons. This plutonium was used to fuel the first nuclear device, "Gadget," tested on July 16, 1945, at the Trinity Site near Alamogordo, New Mexico, as well as for the nuclear weapon "Fat Man" dropped on Nagasaki, Japan, on August 9, 1945.

Technical Details

Natural uranium is composed of approximately 99.27 percent of the isotope uranium 238 and 0.72 percent of uranium 235. The isotope uranium 234 also naturally occurs in very small quantities (approximately 0.0055 percent) as a decay product of uranium 238. Natural uranium has an atomic weight of approximately 238.0508. Uranium is an actinide, chemically similar to actinium, with a density of approximately 19.1 grams per cubic centimeter. Uranium 238 has a half-life of approximately 4.68 billion years, and uranium 235 has a half-life of approximately 703.8 million years.

Uranium 238 is fissionable material. The U-238 nucleus may fission, or split into two smaller nuclei, if it absorbs a fast, or high-energy, neutron, and a U-238 nucleus releases approximately 2.6 additional neutrons when it fissions. U-238 also is a fertile material, that is, it generally does not fission upon absorption of a thermal neutron but may be converted into fissile material through neutron bombardment. When bombarded with thermal neutrons, U-238 may be changed by neutron capture into plutonium, a fissile material.

Uranium 235 is fissile material, which means that it will likely undergo fission when it absorbs a thermal, or low-energy, neutron. Upon absorption of a neutron, U-235 will almost immediately fission, or split into two smaller nuclei. In the fission process, U-235 emits not only energy but also an average of approximately 2.4 neutrons, which may cause additional fission events. If there are enough U-235 atoms present in the material, these additional neutrons may result in a chain reaction.

Additional artificial isotopes of uranium can be made through various processes. Uranium 233, for example, is made through neutron bombardment of the element thorium 232. Uranium 233 is another fissile material that may be used as fuel for reactors. Another example, uranium 239, is a short-lived isotope that has a half-life of about 23 minutes. It decays into neptunium 239, which will further decay into plutonium 239.

Some types of nuclear reactors, such as the Canada Deuterium Uranium (CANDU) Reactor, use natural uranium as fuel (*see* Canada Deuterium Uranium Reactor). However, uranium is generally enriched from its natural state to be used as fuel for nuclear reactors and weapons. Enriching uranium involves increasing the amount of the isotope U-235 present in the material. Reactors in the United States generally require uranium fuel that is enriched to approximately 3 to 5 percent U-235. The U.S. Department of Energy defines highly enriched uranium (HEU), a special nuclear material (SNM), as any uranium that is enriched to 20 percent or higher of U-235. Nuclear weapons generally require "weapons-grade" HEU, which is uranium that is enriched to approximately 90 percent or higher of U-235.

Various forms of uranium are used during most enrichment processes. One such form of uranium is known as "yellowcake," which is a highly concentrated (approximately 70 percent or higher by weight) uranium oxide (U_3O_8). Another form of uranium, which becomes a gaseous compound at temperatures above 133 degrees Fahrenheit, is uranium hexafluoride (UF_6). This gaseous compound, also known simply as "hex," is the form of uranium used to enrich it to higher levels of the isotope U-235. Hex is the form of uranium critical to both of the widely used enrichment techniques, the gaseous-diffusion and gas-centrifuge methods. Following enrichment processes, uranium is converted to uranium dioxide (UO_2) to be used as fuel for reactors.

Current Status

Uranium remains the principal fuel for nuclear reactors today. In 2002, the world produced approximately 46,700 tons of yellowcake. About 1,200 tons of that yellowcake was produced in the United States. The mid-2004 average price of one pound of yellowcake was approximately $18.50. Uranium supplies approximately 17 percent of the world's electricity, which is generated in approximately 440 nuclear reactors. The total output of these reactors is approximately 350,000 million watts of electricity.

HEU is an internationally controlled material by nuclear nonproliferation treaties. The International Atomic Energy Agency (IAEA) helps to monitor and safeguard the world's supply of HEU. As the world's "nuclear watchdog," the IAEA monitors uranium enrichment facilities and the capabilities of the international community.

In 1993, the United States and Russia signed a Highly Enriched Uranium (HEU) Purchase Agreement, which authorizes the United States to purchase 500 metric tons of Russian HEU. The United States will convert the weapons-grade HEU to low enriched uranium fuel for commercial reactors; in the process, approximately 10,000 Russian nuclear weapons will be destroyed. This agreement includes purchasing the HEU over a twenty-year period for more than $12 billion.

One of the current issues pertaining to uranium is the use of depleted uranium (DU) as armor-piercing ammunition for conventional military weapons. Because depleted uranium is nearly two and a half times more dense than steel, it is used to gain greater momentum to penetrate armor by the military. As a heavy metal, DU is toxic if inhaled in sufficient quantities. The prolific use of DU by the United States during Operation Desert Storm in 1991 and subsequent operations caused public concern about the health hazard to soldiers and civilians who breathed in DU dust.

—Don Gillich

See also: Actinides; Atomic Mass/Number/Weight; Depleted Uranium (U-238); Enrichment; Highly Enriched Uranium; Isotopes; Low Enriched Uranium; Neutrons; Nuclear Fuel Cycle; Reactor Operations

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V

VERIFICATION

Verification is the process of ascertaining compliance or noncompliance with an international treaty or other legal or political obligation. The term "verification" is often used synonymously with the term "monitoring," which is the process of observing, inspecting, measuring, and exhibiting military equipment and operations subject to an international treaty or agreement. Verification includes monitoring, but it also includes analyzing the data generated by the monitoring process; assessing this data against established standards of compliance; and weighing other factors such as the political context and importance of the agreement, the past compliance behavior of the monitored party, the risks associated with potential violations, and the effectiveness of prospective responses to those violations. Verification is the collective fusing of both the "monitoring process" and the more analytical and political decision-making "compliance process."

The verification measures for a particular treaty should be sufficient to assure compliance with a high level of confidence, to safeguard national security, and to allow for the detection of noncompliance early enough to permit an appropriate response. The verification processes authorized by the treaty must therefore be reliable enough for inspectors and analysts to detect significant noncompliance in a timely manner. Many technical considerations are taken into account in designing the verification procedures, but the final outcome is often the product of political as much as technical judgments.

History and Background

Throughout the 1960s and 1970s, it was often assumed that there was little need for intrusive verification of arms control agreements between the United States and the Soviet Union. It was presumed that countries did not sign agreements unless they intended to comply with them, that most arms limitation agreements were so modest that there was little incentive for violating them, and that militarily meaningful violations would give themselves away, either because of their inherent magnitude or because they generated dissent within the violating government. As instances of Soviet noncompliance with arms control obligations were increasingly documented throughout the 1980s, however, it became apparent that many of these assumptions were obvious instances of mistakenly attributing the values of an open democratic society to those of a closed, centrally governed state that faced few institutional or political constraints when it came to exploiting arms control as another arena of conflict.

Prior to the treaties that resulted from the Strategic Arms Limitation Talks (SALT I and SALT II) during the 1970s, arms control agreements did not contain explicit provisions for mutual verification, other than to recognize the inherent right of the other parties to employ their own "national technical means" to monitor compliance with the agreement. Verification was undertaken on a unilateral basis without the cooperation of the other side, usually through means of surveillance satellites and other remote sources of information gathering (*see* National Technical Means; Strategic Arms Limitation Talks).

The SALT I agreement, signed in 1972 between the United States and the Soviet Union, incorporated language committing the signatories not to interfere with each other's national technical means of monitoring treaty compliance. It also banned concealment activities except for "current construction, assembly, conversion, or overhaul practices." Although SALT I also created the Standing Consultative Commission as a forum for confidential discussions of verification and compliance concerns between the parties to the treaty, it did not contain any on-site verification provisions.

The SALT II agreement of 1979 carried over the ban on interference with national technical means and the ban on deliberate concealment practices. It added a ban on the encryption of telemetry from missile tests that would impede verification. It also incorporated counting rules for those missile launchers subject to the treaty, provided for the parties to periodically update databases of treaty-limited items, and specified cooperative measures to distinguish between bombers carrying cruise missiles and those that carried only gravity bombs, all to facilitate monitoring compliance with an increasingly complex set of limitations. In many cases, however, the interpretation and implementation of these provisions were left to each side to determine for itself, thus allowing standards of compliance to be established on a unilateral basis and undermining the strategic value of the entire arms control process.

"Trust but Verify"

President Ronald Reagan came into office in 1980 determined to overhaul and improve verification of existing and future arms control agreements. He coined the phrase "trust but verify" to capture these dual objectives.

The Reagan administration not only sought deep reductions in theater and strategic nuclear weapons but also insisted on strict verification measures, including on-site inspections, as a precondition for any further arms limitation agreements with the Soviet Union. Critics of this approach asserted that such a precondition would derail any hope for sustaining the process of strategic nuclear arms control begun under the SALT agreements. But the Soviets eventually conceded, and the Intermediate Nuclear Forces (INF) Treaty, signed in 1987, incorporated intrusive verification measures that would later be used as the model for even more extensive verification provisions in the Strategic Arms Reduction Treaty (START I), signed in 1991. These intrusive measures included annually updated data exchanges on the numbers and locations of treaty-limited systems, a series of baseline inspections to be conducted shortly after the treaty's entry into force, an annual quota of short-notice on-site challenge inspections, continuous monitoring of the perimeters and portals of critical missile production facilities, a complete ban on concealment activities and telemetry encryption, and measures to enhance verification by national technical means, including on-demand open displays of treaty-limited items at missile and bomber bases and submarine ports. START enhanced these measures by adding reciprocal exhibitions of treaty-limited items for visiting inspection teams, stricter conversion and elimination requirements, and more robust open display requirements. Both the INF and START also established commissions to discuss and address issues related to verification and compliance with the respective provisions of the treaties (*see* Data Exchanges; Declared Facility; Intermediate-Range Nuclear Forces Treaty; Strategic Arms Reduction Treaty; Strategic Arms Reduction Treaty).

The Strategic Offensive Reductions Treaty (SORT, also called the Moscow Treaty), signed between the United States and Russia on May 24, 2002, commits both nations to reducing their operational stockpiles of strategic nuclear warheads to no more than 1,700–2,200 by December 31, 2012. Yet it contains no specific verification provisions of its own. Instead, the architects of the Moscow Treaty linked its verification provisions to those contained in START I and II.

—Kerry Kartchner

See also: Arms Control; Confidence- and Security-Building Measures; Implementation; Reconnaissance Satellites; Strategic Offensive Reductions Treaty; Telemetry

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W

WARFIGHTING STRATEGY

"Warfighting strategy" is a term used to describe the strategy of a political entity's armed forces for conducting warfare. Although lacking an official definition, it has gained acceptance as a way to express the means by which military force is employed to achieve objectives within the context of an expected or actual armed conflict. During the Cold War, those who advocated a nuclear counterforce targeting strategy versus a countervalue nuclear doctrine were said to support a particular warfighting strategy. They believed that it was possible for the United States to emerge significantly better off than the Soviet Union from a nuclear conflict. Warfighting theorists believed that the best nuclear deterrent was based on a nuclear warfighting strategy that held at risk Soviet nuclear and conventional military forces and did not simply generate a risk of mutual assured destruction (*see* Counterforce Targeting; Countervalue Targeting; Mutual Assured Destruction).

Strategy relates ends to means. Warfighting, like warfare, is a means to achieve ends that involves the exchange of actual or threatened lethal force between adversaries over time. Historically, the means of a warfighting strategy have included the full range of military capabilities, from sword-bearing infantry to missile-delivered weapons of mass destruction. Likewise, the ends have reflected the entire spectrum of political objectives espoused by city-states, feudal kingdoms, nation-states, and others. Around 500 B.C., for example, Sun Tzu articulated a warfighting strategy for the Chinese Kingdom of Wu that emphasized the use of deception to disrupt an adversary's plans and alliances in order to achieve victory, ideally without even fighting. During World War II, the Nazi regime of Germany implemented a warfighting strategy known as "Blitzkrieg" that integrated land and air forces to overwhelm the adversary through speed and force. North Vietnam effectively employed a guerrilla-warfare strategy against France and the United States, and Al Qaeda, the violent nonstate actor centered in the Middle East, relies on terrorism as a warfighting strategy.

In its customary usage, warfighting strategy is a form of military strategy, which is the art and science of employing the armed forces of a nation to secure the objectives of the national policy by the application of force or threat of force. Military strategy is derived from national strategy, which is the art and science of developing and using political, economic, military, and informational powers during peace and war to secure policy objectives. Warfighting strategy has application at all levels of war: strategic, operational, and tactical. At the strategic level, it links the military capabilities of a nation-state to specific security objectives as articulated in global or regional strategic plans. It guides the development and structuring of military forces, including such overarching operational concepts as nuclear deterrence, power projection with conventional forces, or information superiority. It is more often used to refer to warfare at the operational level. It guides the planning and conduct of actual military campaigns and major operations. In addition to reflecting broad concepts such as offense, defense, mobility, and asymmetry, warfighting strategy addresses the role of specific capabilities, such as airpower, in achieving outcomes, such as air supremacy, in relation to overall campaign objectives, such as the annihilation of an enemy's armed forces. Its use at the operational level impacts the tactical level by shaping when and how specific battles will be fought.

—*Troy S. Thomas*

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WARHEAD

The term "warhead" generally refers to the weapon that is mounted inside the nose cone and reentry vehicle of a ballistic or guided missile. Warhead construction is challenging because it entails developing a weapon that not only can withstand the vibration and acceleration involved in rocket flight but also survive the heat of reentry into the atmosphere. Warheads have to be hardened against the electromagnetic pulse that is generated in a nuclear detonation to reduce the chances of fratricide. Warheads also must be equipped with safety features that render them harmless if they are subject to tampering, and they must be capable of being stored or deployed atop operational delivery systems for relatively long periods. In the case of earth-penetrating weapons, warheads also have to be designed to withstand the shock of impact with the ground.

Nuclear warheads designed for ballistic missiles also must meet stringent weight and shape requirements to conform to the lift capability of missiles and the shape of reentry vehicles. Although early reentry vehicles had long, needle-like designs, reentry vehicles that had a blunt body shape were the most efficient way to dissipate the heat generated upon reentry into the Earth's atmosphere. Blunt body vehicles, however, were slow to reenter the atmosphere, making them a relatively easy target for antiballistic missile systems. Cone-shaped reentry vehicles, coated with an ablative material that would literally burn and flake off during reentry, cooling the warhead inside, were chosen as the ideal shape to minimize reentry time. The shape of the reentry vehicle forced nuclear weapons designers to develop complementary weapons designs.

—James J. Wirtz

See also: Ballistic Missiles; Command and Control; Missile Defense; Payload; Reentry Vehicles

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WARSAW PACT

The Warsaw Pact was a formal alliance established on May 14, 1955, by the Warsaw Treaty of Friendship, Cooperation, and Mutual Assistance between Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, and the Soviet Union. Following the principles laid out in Article 51 of the United Nations Charter, the pact was designed for collective self-defense of the member states against external aggression. The Soviet Union claimed that it was formed in response to the Federal Republic of Germany joining the North Atlantic Treaty Organization (NATO). The pact also facilitated Soviet political control of Eastern Europe by authorizing the Soviet Union to station forces in Warsaw Pact territory. Soviet policy provided the main directive to Warsaw Pact plans through the Political Consultative Committee (PCC) as the highest alliance organ, although the pact stated that relations among the signatories were based on equality and respect for national sovereignty and independence. Soviet political intentions and its disrespect for national sovereignty and independence were clearly demonstrated, however, in 1968, when the pact employed military force for the only time against one of its own members, Czechoslovakia. The forces that entered Czechoslovakia in August 1968 to halt the revolutionary movement toward democracy were made up of twenty-three Soviet divisions with only six divisions from other members.

The détente period in the 1970s witnessed relatively stable Soviet–East European relations. Joint Warsaw Pact exercises during this time emphasized offensive capabilities. In the late 1970s, Soviet deployment of SS-20 intermediate-range ballistic missiles (IRBMs) in Warsaw Pact countries increased tensions in Europe, and the United States responded by deploying Pershing II IRBMs.

The Warsaw Pact had a larger ground force of infantry, tanks, and artillery than NATO and was largely made up of Soviet armed forces. Many believed that the Warsaw Pact could have defeated NATO in a conventional war. The Soviet and Warsaw Pact aim was for "effective occupation" of Central Europe within hours of an offensive as a means of quickly acquiring territorial bargaining counters in the event of a ceasefire. Soviet military strategists planned to defeat NATO decisively before its political and military command structure could decide how to respond to a Soviet attack. Warsaw Pact forces undertook extensive nuclear, biological, and chemical (NBC) training, and tactical nuclear strikes at key targets may have been considered. Warsaw Pact maneuvers centered on the postnuclear phase of hostilities, a clear indicator of what was expected. Given the desire for speedy acquisition of territory, pact strategists may have thought that a chemical and biological attack could reduce the danger of a nuclear counterattack against Warsaw Pact troops, leaving the economic potential of Western Europe relatively intact.

By the mid-1980s, the future of the Warsaw Pact hinged on Soviet premier Mikhail Gorbachev's emerging policy of liberalization toward Eastern Europe. At the U.S.S.R.'s Twenty-Seventh Party Congress in 1986, Gorbachev acknowledged that differences existed among the Soviet allies. In 1987, the Warsaw Pact, under Soviet tutelage, adopted a defense-oriented military doctrine. In July 1991, as the Cold War was ending, the members agreed to terminate their thirty-six year alliance.

—J. Simon Rofe

See also: Cold War; Détente

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WASSENAAR ARRANGEMENT

The Wassenaar Arrangement is a voluntary export control regime created in 1996. Most of the world's leading arms exporters participate in the arrangement. The regime seeks to prevent destabilizing accumulations of arms anywhere in the world and its members consult on arms deals with non-Wassenaar states. The thirty-three members of the arrangement meet annually in a plenary session.

The agreement calls upon members to subject small arms and light weapons to national export controls, using guidelines drawn up based on best practices that specify criteria to be used when assessing a possible arms sale. For example, a sale should be avoided if the members believe the weapons could end up in the hands of terrorists or organized crime. Members report on exports of dual-use goods and technologies as well as on seven categories of conventional weapons: battle tanks, armored combat vehicles, large-caliber artillery, military aircraft and unmanned aerial vehicles, military and attack helicopters, warships, and missiles or missile systems.

—Jeffrey A. Larsen

See also: Dual-Use; Nonproliferation; Nuclear Supplies Group

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WEAPONS-GRADE MATERIAL

The acquisition of weapons-grade material—nuclear material considered most suitable for making nuclear weapons—is the most formidable obstacle to the manufacture of nuclear weapons. The primary weapons-grade materials are uranium enriched to 90 percent or greater uranium 235 (U-235) or plutonium with greater than about 90 percent plutonium 239 (Pu-239). These elements are called "fissile" because they can be split into two roughly equal-mass fragments when struck by a neutron of even low energy. When a large enough mass of either material is assembled, a self-sustaining chain reaction is produced after the first fission. For the nuclear explosive to obtain a significant nuclear yield, sufficient neutrons must be present within the weapon core at the right time. If the chain reaction starts too soon or too late, the result will be only a "fizzle" yield or no yield at all (*see* Fission Weapons).

Plutonium is used by all of the current nuclear weapons states: the United States, Russia, Great Britain, France, China, Israel, India, and Pakistan. (South Africa built six nuclear weapons in the 1980s and early 1990s using U-235, but it subsequently destroyed these weapons and dismantled its weapons program.) Pu-239 does not occur in nature. It can be made only in quantities sufficient for constructing a weapon in a nuclear reactor. It must be "bred," or produced, one atomic nucleus at a time by bombarding U-238 with neutrons to produce the isotope U-239, which, as it beta-decays, emits an electron to become the radioactive neptunium 239 (Np-239). The neptunium isotope again beta-decays to become Pu-239. The only proven and practical source for the large quantities of neutrons needed to make plutonium at a reasonable speed is a nuclear reactor in which a controlled but self-sustaining U-235 fission chain reaction takes place. The plutonium then must be extracted chemically in a reprocessing plant, making this route to nuclear weapons production relatively difficult to conceal.

U-235 is the other significant weapons-grade material. The only naturally occurring fissile isotope, natural uranium contains only about 0.7 percent U-235, the rest being largely the less fissionable isotope U-238 (which cannot sustain a chain reaction). To use uranium either as a fuel for nuclear reactors or as the explosive charge of a nuclear weapon, U-235 must be separated from the rest of the uranium by a process known as "enrichment."

The first nuclear weapons the United States developed contained a hollow ball of plutonium surrounded by conventional explosives. When these explosives were detonated, the resulting force, focused inward, compressed the plutonium, thereby initiating a chain reaction. The United States first detonated this kind of bomb during the Trinity test near Alamogordo, New Mexico, on July 16, 1945, and then it dropped another, called "Fat Man," on Nagasaki, Japan, a few weeks later, on August 9. These two devices were implosion devices (*see* Implosion Devices). The nuclear bomb the United States dropped on Hiroshima, "Little Boy," on August 6 detonated when one chunk of U-235 was fired down a tube into another piece of U-235. This type, known as a gun-assembly device, is the easiest of all nuclear devices to design and build and did not require testing (*see* Gun-Type Devices). It is generally believed to be impossible to prevent any nation having the requisite amount of enriched uranium from building one or more gun-type weapons. Therefore, the acquisition of significant quantities of U-235 or a facility in which to separate the fissile material is an indicator that the acquiring state could be in the process of gaining a rudimentary nuclear capability.

—*Peter Lavoy*

See also: Enrichment; Highly Enriched Uranium; Isotopes; Plutonium; Reprocessing; Uranium

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WEAPONS OF MASS DESTRUCTION (WMD)

Although the term "weapon of mass destruction" (WMD) has been in use for more than thirty-five years, it has no widely accepted definition. Only one international agreement uses the term: The 1967 Outer Space Treaty bans "nuclear weapons or any other kinds of weapons of mass destruction" from Earth orbit or on celestial bodies (*see* Outer Space Treaty). The term "WMD" sometimes is used to identify weapons considered beyond civilized norms that should be banned or at least internationally controlled.

One working definition for WMD might be weapons that can create more than a hundred times the casualties expected from an equivalent mass of high explosive and that can cause severe contamination to an area requiring millions of dollars and months of work in cleanup and rebuilding efforts in order for safe use to resume. Most definitions of WMD list biological, chemical, radiological, or nuclear weapons. These four types of weapons can affect large areas and large numbers of people, especially in comparison with conventional weapons targeted at specific soldiers, vehicles, or buildings. In addition, all four can produce effects that spread far beyond their original target area and contaminate a large area for a long time after use.

WMD Effects

There are significant differences among the four kinds of WMD in terms of effects, difficulty of acquisition and delivery, and expectations about use. Nuclear weapons are the only type of WMD that destroy structures and equipment as well as killing people. No form of protection is effective against nuclear blast effects.

Pound for pound, biological weapons can produce even more casualties than nuclear weapons, but biological weapons are more dependent on environmental conditions and random factors. With sufficient warning, military forces can protect themselves against biological weapons; for many agents, civilian populations also can be treated after an attack is discovered. Biological agents do not usually produce instant death or even incapacitation; they often take hours or days to produce effects. Some people may even have natural immunity to a biological agent.

Chemical weapons must be delivered in vast quantities to cause massive casualties. When warned, military authorities can have troops use protective gear to reduce the number of casualties suffered during a chemical weapons attack. When not protected, however, exposed individuals may experience a nearly instant agonizing death from just drops of certain chemical agents.

Radiological weapons might produce more panic from fear of radiation than actual death. In theory, radioactive debris could be spread over a large area using conventional explosives laced with fissile material. Radiological weapons require large quantities of material to produce a delayed effect that can be defeated with protective clothing and through decontamination efforts (*see* Nuclear Weapons Effects).

Acquisition and Delivery

Nuclear weapons are probably the most difficult type of WMD to acquire because specialized equipment and knowledge is required to develop and test them. Nuclear weapons production relies on complex and unique equipment and the procurement of weapons-grade fissionable materials that must be carefully controlled. Meeting the requirements to construct nuclear weapons is a challenge for nations and may be beyond the ability of nonstate groups. Terrorist groups, however, may be able to acquire a weapon on the black market or through theft.

In contrast, biological weapons can be created using commercial equipment in a relatively small facility, and even small amounts can be deadly. They can be distributed easily, as shown in the U.S. anthrax attacks that occurred in the fall of 2001. Production of chemical weapons in quantity requires chemical engineering expertise and chemical production facilities on a scale similar to that of petroleum refineries. Aircraft sprayers and artillery delivery are preferred for battlefield use, but pressurized tanks can suffice at any scale.

Radioactive material suitable for radiological weapons is readily available given its widespread use in medical and research applications. Delivery of radiological weapons by means of aerial dusting would affect the largest possible area, but recent concern has centered on the possible terrorist employment of so-called dirty bombs, that is, conventional explosive devices used for dispersing nuclear material. Explosive dispersal is unlikely to produce any deaths from radiation but could require an expensive and time-consuming decontamination cleanup effort to make the area safe for human occupation (*see* Radiological Dispersal Device).

Despite the potential for chemical, biological, radiological, and nuclear weapons to produce large-scale death and destruction, weapons of mass destruction have primarily served as tools of deterrence by nations attempting to prevent their use by adversaries.

—*Roy Pettis*

See also: Deterrence

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X

X-RAY LASER

The concept of an X-ray laser dates to the early 1970s, when physicists realized that laser beams amplified with ions had more energy than beams amplified using gases. It was thought that nuclear explosions might serve as the power supply for such high-energy lasers. The Strategic Defense Initiative (SDI) proposed relying on a nuclear-powered laser to destroy intercontinental ballistic missiles (ICBMs) while in flight.

One of the goals of SDI was to place satellites with nuclear devices into orbit. These satellites would bristle with glass rods to serve as laser guides. Upon detonation of the nuclear device, X-ray photons in the atoms making up the rods would be excited. This would lead to optical amplification of the X-ray photons to produce an X-ray laser beam that would be minimally affected by atmospheric distortion (which diffuses light beams produced by conventional chemical lasers). The X-ray laser would be capable of destroying ICBMs in flight. It would strictly be a one-shot device, destroying itself when the nuclear weapon detonated and fired the laser. A test of the concept, code-named Correo, took place at the Nevada Test Site in 1984. Research into space-based X-ray lasers ended after the cancellation of the SDI program.

The SDI program brought about greater understanding of the physics of X-ray lasers and produced new computer codes for modeling plasmas. It also contributed to the development of a laboratory X-ray laser for biological imaging. Coupling X-ray lasers with X-ray microscopes, scientists at the Lawrence Livermore National Laboratory in Livermore, California, have created three-dimensional holograms of living organisms and developed new materials for commercial use.

—Gilles Van Nederveen

See also: Missile Defense; Strategic Defense Initiative

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Y

YELLOWCAKE

See Enrichment; Highly Enriched Uranium

YIELD

"Yield" refers to the energy released in a nuclear detonation. Although this energy takes the form of blast, thermal and nuclear radiation, and electromagnetic pulse, yield usually describes just the blast produced by a device. It is commonly expressed in terms of kilotons (thousands of tons) or megatons (millions of tons) of the equivalent quantity of trinitrotoluene (TNT) required to produce the same amount of energy.

The focus of early nuclear weapons design efforts was to build weapons with increasingly higher yields. The highest-yield device tested by the United States was approximately 15 megatons. The former Soviet Union tested a device that was in excess of 50 megatons.

Albert Einstein's mass-energy equivalence equation ($E = mc^2$) implies that mass can be converted into energy. The energy released in the mass conversion in fission and fusion is thousands to millions of times greater than that released in a chemical process. The yield of a weapon is determined by the amount of nuclear fuel available and its efficiency, that is, how much of the available fuel actually undergoes fission or fusion. A higher yield generally produces greater destructive effects.

—Don Gillich

See also: Fission Weapons; Kilotons; Megatons; Nuclear Weapons Effects

Reference

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Z

ZANGGER COMMITTEE

In 1971, following the entry into force of the Nuclear Nonproliferation Treaty (NPT), the Zangger Committee was formed as the first international effort to control exports of nuclear dual-use technologies. The committee was composed of major nuclear supplier nations that were party to the NPT. Their mission was to interpret the vague safeguard requirements of Article III.2 of the NPT that addressed the export of nuclear equipment and material.

The committee concluded that an exporter had limited responsibility to ensure that materials being exported would be placed under International Atomic Energy Agency safeguards and that the exporter had no responsibility to ensure that the entirety of an importer's program be safeguarded. The committee also concluded that the NPT was not responsible for the creation of binding international export controls and that nations had to devise their own policies to police their own exports. This interpretation of what was required by the NPT was considered too loose by many and represented the ongoing tension between the desire to prevent potential proliferation to nuclear-aspiring nations while maintaining the right to transfer nuclear technologies and materials for peaceful purposes.

Zangger Committee members entered into an ad hoc voluntary agreement that was not formally connected to the NPT in which they agreed not to export certain items without first ensuring that they would be safeguarded. They developed a so-called Trigger List that contained agreed-upon items that could not be exported in the absence of safeguards to prevent diversion into covert nuclear weapons programs.

The Zangger Committee laid the groundwork for the Nuclear Suppliers Group (NSG) and other nonproliferation voluntary agreements. Its Trigger List was incorporated and extended by the NSG and is a significant contribution to the current nuclear nonproliferation regime.

—*Jennifer Hunt Morstein*

See also: Nonproliferation; Nuclear Nonproliferation Treaty; Nuclear Suppliers Group; Safeguards

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ZERO OPTION

See Intermediate-Range Nuclear Forces Treaty

ZONE OF PEACE

The term "zone of peace" was first applied to a geographical region in the international community when, in 1970, the Lusaka Non-Aligned Summit called upon all leaders to "respect the Indian Ocean as a zone of peace from which Great Power rivalries and competition" would be banned. Indian officials also wanted to use the zone-of-peace concept to exclude U.S. and UK military units from the region and eliminate foreign military bases, for example, the British base on the island of Diego Garcia. In 1966, the United States had signed a treaty with the United Kingdom making the island available for U.S. military operations. During the Cold War, the base was an important forward operating post used to counter growing Soviet influence in Asia and Africa.

Sri Lanka diplomats introduced the Indian Ocean Zone of Peace (IOZOP) proposal into the UN General Assembly with Resolution 2832 in 1971. In the same year, Malaysia unveiled a similar proposal for a Zone of Peace, Freedom and Neutrality (ZOPFAN).

In 1972, the UN formed the Ad Hoc Committee on the Indian Ocean. The committee focused on preparing for an Indian Ocean conference that would lead to an agreement to implement the

IOZOP. Because committee members were unable to overcome fundamental disagreements, the conference never convened. IOZOP and ZOPFAN efforts to reduce superpower rivalry in the region failed because Cold War tensions were too difficult for smaller countries, even those operating collectively, to resolve. Zone-of-peace proponents also failed to realize that not everyone believed that Great Power involvement in the Indian Ocean was counter to their interests. Several states, including Australia, welcomed the U.S. Navy in the Indian Ocean as a stabilizing influence in South Asia.

Owing to the strong opposition of the United States, the United Kingdom, and France, the IOZOP initiative has made little diplomatic progress since it was first proposed. Given the usefulness of Diego Garcia as a base of operations in the global war against terrorism, future zone-of-peace negotiations or discussions are unlikely to be taken seriously by the United States, Britain, or even India, for that matter. In fact, the United States has called for terminating the Ad Hoc Committee as a way to reduce the UN's administrative costs.

In addition to the Indian Ocean and Malaysian zones-of-peace proposals, there have been proposals for zones of peace in Central America, South America, and for specific countries such as Tibet and El Salvador. The proposals generally call for excluding foreign powers from the region or state, stopping the flow of arms into the region, and creating a climate for reestablishing regional or national peace and security in the face of regional or internal civil wars. So far, however, none of the proposals have been implemented.

—Guy Roberts

See also: Nuclear Weapons Free Zones

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Purposes, Guidelines, and Procedures, 535

Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems

Signed at Moscow May 26, 1972
Ratification advised by U.S. Senate August 3, 1972
Ratified by U.S. President September 30, 1972
Entered into force October 3, 1972

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Proceeding from the premise that nuclear war would have devastating consequences for all mankind,

Considering that effective measures to limit anti-ballistic missile systems would be a substantial factor in curbing the race in strategic offensive arms and would lead to a decrease in the risk of outbreak of war involving nuclear weapons,

Proceeding from the premise that the limitation of anti-ballistic missile systems, as well as certain agreed measures with respect to the limitation of strategic offensive arms, would contribute to the creation of more favorable conditions for further negotiations on limiting strategic arms,

Mindful of their obligations under Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons,

Declaring their intention to achieve at the earliest possible date the cessation of the nuclear arms race and to take effective measures toward reductions in strategic arms, nuclear disarma-ment, and general and complete disarmament,

Desiring to contribute to the relaxation of international tension and the strengthening of trust between States,

Have agreed as follows:

ARTICLE I

1. Each Party undertakes to limit anti-ballistic missile (ABM) systems and to adopt other measures in accordance with the provisions of this Treaty.
2. Each Party undertakes not to deploy ABM systems for a defense of the territory of its country and not to provide a base for such a defense, and not to deploy ABM systems for defense of an individual region except as provided for in Article III of this Treaty.

ARTICLE II

1. For the purpose of this Treaty an ABM system is a system to counter strategic ballistic missiles or their elements in flight trajectory, currently consisting of:
   (a) ABM interceptor missiles, which are interceptor missiles constructed and deployed for an ABM role, or of a type tested in an ABM mode;
   (b) ABM launchers, which are launchers constructed and deployed for launching ABM interceptor missiles; and
   (c) ABM radars, which are radars constructed and deployed for an ABM role, or of a type tested in an ABM mode.
2. The ABM system components listed in paragraph 1 of this Article include those which are:
   (a) operational;
   (b) under construction;
   (c) undergoing testing;
   (d) undergoing overhaul, repair or conversion; or
   (e) mothballed.

ARTICLE III

Each Party undertakes not to deploy ABM systems or their components except that:

(a) within one ABM system deployment area having a radius of one hundred and fifty kilometers and centered on the Partys national capital, a Party may deploy: (1) no more than one hundred ABM launchers and no more than one hundred ABM interceptor missiles at launch sites, and (2) ABM radars within no more than six ABM radar complexes, the area of each complex being circular and having a diameter of no more than three kilometers; and
(b) within one ABM system deployment area having a radius of one hundred and fifty kilometers and containing ICBM silo launchers, a Party may deploy: (1) no more than one hundred ABM launchers and no more than one hundred ABM interceptor missiles at launch sites, (2) two large phased-array ABM radars comparable in potential to corresponding ABM radars operational or under construction on the date of signature of the Treaty in an ABM system deployment area containing ICBM silo launchers, and (3) no more than eighteen ABM

radars each having a potential less than the potential of the smaller of the above-mentioned two large phased-array ABM radars.

ARTICLE IV

The limitations provided for in Article III shall not apply to ABM systems or their components used for development or testing, and located within current or additionally agreed test ranges. Each Party may have no more than a total of fifteen ABM launchers at test ranges.

ARTICLE V

1. Each Party undertakes not to develop, test, or deploy ABM systems or components which are sea-based, air-based, space-based, or mobile land-based.
2. Each Party undertakes not to develop, test or deploy ABM launchers for launching more than one ABM interceptor missile at a time from each launcher, not to modify deployed launchers to provide them with such a capacity, not to develop, test, or deploy automatic or semi-automatic or other similar systems for rapid reload of ABM launchers.

ARTICLE VI

To enhance assurance of the effectiveness of the limitations on ABM systems and their components provided by the Treaty, each Party undertakes:

(a) not to give missiles, launchers, or radars, other than ABM interceptor missiles, ABM launchers, or ABM radars, capabilities to counter strategic ballistic missiles or their elements in flight trajectory, and not to test them in an ABM mode; and
(b) not to deploy in the future radars for early warning of strategic ballistic missile attack except at locations along the periphery of its national territory and oriented outward.

ARTICLE VII

Subject to the provisions of this Treaty, modernization and replacement of ABM systems or their components may be carried out.

ARTICLE VIII

ABM systems or their components in excess of the numbers or outside the areas specified in this Treaty, as well as ABM systems or their components prohibited by this Treaty, shall be destroyed or dismantled under agreed procedures within the shortest possible agreed period of time.

ARTICLE IX

To assure the viability and effectiveness of this Treaty, each Party undertakes not to transfer to other States, and not to deploy outside its national territory, ABM systems or their components limited by this Treaty.

ARTICLE X

Each Party undertakes not to assume any international obligations which would conflict with this Treaty.

ARTICLE XI

The Parties undertake to continue active negotiations for limitations on strategic offensive arms.

ARTICLE XII

1. For the purpose of providing assurance or compliance with the provisions of this Treaty, each Party shall use national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law.
2. Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph 1 of this Article.
3. Each Party undertakes not to use deliberate concealment measures which impede verification by national technical means of compliance with the provisions of this Treaty. This obligation shall not require changes in current construction, assembly, conversion, or overhaul practices.

ARTICLE XIII

1. To promote the objectives and implementation of the provisions of this Treaty, the Parties shall establish promptly a Standing Consultative Commission, within the framework of which they will:
(a) consider questions concerning compliance with the obligations assumed and related situations which may be considered ambiguous;
(b) provide on a voluntary basis such information as either Party considers necessary to assure confidence in compliance with the obligations assumed;
(c) consider questions involving unintended interference with national technical means of verification;
(d) consider possible changes in the strategic situation which have a bearing on the provisions of this Treaty;
(e) agree upon procedures and dates for destruction or dismantling of ABM systems or their components in cases provided for by the provisions of this Treaty;
(f) consider, as appropriate, possible proposals for further increasing the viability of this Treaty; including proposals for amendments in accordance with the provisions of this Treaty;
(g) consider, as appropriate, proposals for further measures aimed at limiting strategic arms.
2. The Parties through consultation shall establish, and may amend as appropriate, Regulations for the Standing Consultative Commission governing procedures, composition and other relevant matters.

ARTICLE XIV

1. Each Party may propose amendments to this Treaty. Agreed amendments shall enter into force in accordance with the procedures governing the entry into force of this Treaty.
2. Five years after entry into force of this Treaty, and at five-year intervals thereafter, the Parties shall together conduct a review of this Treaty.

ARTICLE XV

1. This Treaty shall be of unlimited duration.
2. Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests. It shall give notice of its decision to the other Party six months prior to withdrawal from the Treaty. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests.

ARTICLE XVI

1. This Treaty shall be subject to ratification in accordance with the constitutional procedures of each Party. The Treaty shall enter into force on the day of the exchange of instruments of ratification.
2. This Treaty shall be registered pursuant to Article 102 of the Charter of the United Nations.

DONE at Moscow on May 26, 1972, in two copies, each in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES OF AMERICA:
RICHARD NIXON
President of the United States of America
FOR THE UNION OF SOVIET SOCIALIST REPUBLICS:
L. I. BREZHNEV
General Secretary of the Central Committee of the CPSU

Agreed Framework Between the United States of America and the Democratic People's Republic of Korea

October 21, 1994

Delegations of the Governments of the United States of America (U.S.) and the Democratic People's Republic of Korea (DPRK) held talks in Geneva from September 23 to October 17, 1994, to negotiate an overall resolution of the nuclear issue on the Korean Peninsula.

Both sides reaffirmed the importance of attaining the objectives contained in the August 12, 1994 Agreed Statement between the U.S. and the DPRK and upholding the principles of the June 11, 1993 Joint Statement of the U.S. and the DPRK to achieve peace and security on a nuclear-free Korean peninsula. The U.S. and the DPRK decided to take the following actions for the resolution of the nuclear issue:

I.

Both sides will cooperate to replace the DPRK's graphite-moderated reactors and related facilities with light-water reactor (LWR) power plants.

1) In accordance with the October 20, 1994 letter of assurance from the U.S. President, the U.S. will undertake to make arrangements for the provision to the DPRK of a LWR project with a total generating capacity of approximately 2,000 MW(e) by a target date of 2003.

- The U.S. will organize under its leadership an international consortium to finance and supply the LWR project to be provided to the DPRK. The U.S., representing the international consortium, will serve as the principal point of contact with the DPRK for the LWR project.
- The U.S., representing the consortium, will make best efforts to secure the conclusion of a supply contract with the DPRK within six months of the date of this Document for the provision of the LWR project. Contract talks will begin as soon as possible after the date of this Document.
- As necessary, the U.S. and the DPRK will conclude a bilateral agreement for cooperation in the field of peaceful uses of nuclear energy.

2) In accordance with the October 20, 1994 letter of assurance from the U.S. President, the U.S., representing the consortium, will make arrangements to offset the energy foregone due to the freeze of the DPRK's graphite-moderated reactors and related facilities, pending completion of the first LWR unit.

- Alternative energy will be provided in the form of heavy oil for heating and electricity production.
- Deliveries of heavy oil will begin within three months of the date of this Document and will reach a rate of 500,000 tons annually, in accordance with an agreed schedule of deliveries.

3) Upon receipt of U.S. assurances for the provision of LWR's and for arrangements for interim energy alternatives, the DPRK will freeze its graphite-moderated reactors and related facilities and will eventually dismantle these reactors and related facilities.

- The freeze on the DPRK's graphite-moderated reactors and related facilities will be fully implemented within one month of the date of this Document. During this one-month period, and throughout the freeze, the International Atomic Energy Agency (IAEA) will be allowed to monitor this freeze, and the DPRK will provide full cooperation to the IAEA for this purpose.
- Dismantlement of the DPRK's graphite-moderated reactors and related facilities will be completed when the LWR project is completed.
- The U.S. and DPRK will cooperated in finding a method to store safely the spent fuel from the 5 MW(e) experimental reactor during the construction of the LWR project, and to dispose of the fuel in a safe manner that does not involve reprocessing in the DPRK.

4) As soon as possible after the date of this document. U.S. and DPRK experts will hold two sets of experts talks.

- At one set of talks, experts will discuss issues related to alternative energy and the replacement of the graphite-moderated reactor program with the LWR project.
- At the other set of talks, experts will discuss specific arrangements for spent fuel storage and ultimate disposition.

II.

The two sides will move toward full normalization of political and economic relations.

1) Within three months of the date of this Document, both sides will reduce barriers to trade and investment, including restrictions on telecommunications services and financial transactions.

2) Each side will open a liaison office in the other's capital following resolution of consular and other technical issues through expert level discussions.

3) As progress is made on issues of concern to each side, the U.S. and DPRK will upgrade bilateral relations to the

Ambassadorial level.

III.

Both sides will work together for peace and security on a nuclear-free Korean peninsula.

1) The U.S. will provide formal assurances to the DPRK, against the threat or use of nuclear weapons by the U.S.

2) The DPRK will consistently take steps to implement the North-South Joint Declaration on the Denuclearization of the Korean peninsula.

3) The DPRK will engage in North-South dialogue, as this Agreed Framework will help create an atmosphere that promotes such dialogue.

IV.

Both sides will work together to strengthen the international nuclear non-proliferation regime.

1) The DPRK will remain a party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and will allow implementation of its safeguards agreement under the Treaty.

2) Upon conclusion of the supply contract for the provision of the LWR project, ad hoc and routine inspections will resume under the DPRK's safeguards agreement with the IAEA with respect to the facilities not subject to the freeze. Pending conclusion of the supply contract, inspections required by the IAEA for the continuity of safeguards will continue at the facilities not subject to the freeze.

3) When a significant portion of the LWR project is completed, but before delivery of key nuclear components, the DPRK will come into full compliance with its safeguards agreement with the IAEA (INFCIRC/403), including taking all steps that may be deemed necessary by the IAEA, following consultations with the Agency with regard to verifying the accuracy and completeness of the DPRK's initial report on all nuclear material in the DPRK.

Kang Sok Ju- Head of the Delegation for the Democratic People's Republic of Korea, First Vice-Minister of Foreign Affairs of the Democratic People's Republic of Korea

Robert L. Gallucci- Head of the Delegation of United States of America, Ambassador at Large of the United States of America

The Antarctic Treaty (1959)

The Governments of Argentina, Australia, Belgium, Chile, the French Republic, Japan, New Zealand, Norway, the Union of South Africa, the Union of Soviet Socialist Republics, the United Kingdom of Great Britain and Northern Ireland, and the United States of America,

Recognizing that it is in the interest of all mankind that Antarctica shall continue for ever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord;

Acknowledging the substantial contributions to scientific knowledge resulting from international cooperation in scientific investigation in Antarctica;

Convinced that the establishment of a firm foundation for the continuation and development of such cooperation on the basis of freedom of scientific investigation in Antarctica as applied during the International Geophysical Year accords with the interests of science and the progress of all mankind;

Convinced also that a treaty ensuring the use of Antarctica for peaceful purposes only and the continuance of international harmony in Antarctica will further the purposes and principles embodied in the Charter of the United Nations;

Have agreed as follows:

ARTICLE I

1. Antarctica shall be used for peaceful purposes only. There shall be prohibited, inter alia , any measure of a military nature, such as the establishment of military bases and fortifications, the carrying out of military manoeuvres, as well as the testing of any type of weapon.

2. The present Treaty shall not prevent the use of military personnel or equipment for scientific research or for any other peaceful purpose.

ARTICLE II

Freedom of scientific investigation in Antarctica and cooperation toward that end, as applied during the International Geophysical Year, shall continue, subject to the provisions of the present Treaty.

ARTICLE III

1. In order to promote international cooperation in scientific investigation in Antarctica, as provided for in Article II of the present Treaty, the Contracting Parties agree that, to the greatest extent feasible and practicable:

a. information regarding plans for scientific programs in Antarctica shall be exchanged to permit maximum economy of and efficiency of operations;
b. scientific personnel shall be exchanged in Antarctica between expeditions and stations;
c. scientific observations and results from Antarctica shall be exchanged and made freely available.

ARTICLE IV

1. Nothing contained in the present Treaty shall be interpreted as:

a. a renunciation by any Contracting Party of previously asserted rights of or claims to territorial sovereignty in Antarctica;
b. a renunciation or diminution by any Contracting Party of any basis of claim to territorial sovereignty in Antarctica which it may have whether as a result of its activities or those of its nationals in Antarctica, or otherwise;
c. prejudicing the position of any Contracting Party as regards its recognition or non-recognition of any other StateÇs rights of or claim or basis of claim to territorial sovereignty in Antarctica.

2. No acts or activities taking place while the present Treaty is in force shall constitute a basis for asserting, supporting or denying a claim to territorial sovereignty in Antarctica or create any rights of sovereignty in Antarctica. No new claim, or enlargement of an existing claim, to territorial sovereignty in Antarctica shall be asserted while the present Treaty is in force.

ARTICLE V

1. Any nuclear explosions in Antarctica and the disposal there of radioactive waste material shall be prohibited.

2. In the event of the conclusion of international agreements concerning the use of nuclear energy, including nuclear explosions and the disposal of radioactive waste material, to which all of the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article IX are parties, the rules established under such agreements shall apply in Antarctica.

ARTICLE VI

The provisions of the present Treaty shall apply to the area south of 60∞ South Latitude, including all ice shelves, but nothing in the present Treaty shall prejudice or in any way affect the rights, or the exercise of the rights, of any State under international law with regard to the high seas within that area.

ARTICLE VII

1. In order to promote the objectives and ensure the observance of the provisions of the present Treaty, each Contracting Party whose representatives are entitled to participate in the meetings referred to in Article IX of the Treaty shall have the right to designate observers to carry out any inspection provided for by the present Article. Observers shall be nationals of the Contracting Parties which designate them. The names of observers shall be communicated to every other Contracting Party having the right to designate observers, and like notice shall be given of the termination of their appointment.

2. Each observer designated in accordance with the provisions of paragraph 1 of this Article shall have complete freedom of access at any time to any or all areas of Antarctica.

3. All areas of Antarctica, including all stations, installations and equipment within those areas, and all ships and aircraft at points of discharging or embarking cargoes or personnel in Antarctica, shall be open at all times to inspection by any observers designated in accordance with paragraph 1 of this Article.

4. Aerial observation may be carried out at any time over any or all areas of Antarctica by any of the Contracting Parties having the right to designate observers.

5. Each Contracting Party shall, at the time when the present Treaty enters into force for it, inform the other Contracting Parties, and thereafter shall give them notice in advance, of

a. all expeditions to and within Antarctica, on the part of its ships or nationals, and all expeditions to Antarctica organized in or proceeding from its territory;
b. all stations in Antarctica occupied by its nationals; and
c. any military personnel or equipment intended to be introduced by it into Antarctica subject to the conditions prescribed in paragraph 2 of Article I of the present Treaty.

ARTICLE VIII

1. In order to facilitate the exercise of their functions under the present Treaty, and without prejudice to the respective positions of the Contracting Parties relating to jurisdiction over all other persons in Antarctica, observers designated under paragraph 1 of Article VII and scientific personnel exchanged under sub-paragraph 1(b) of Article III of the Treaty, and members of the staffs accompanying any such persons, shall be subject only to the jurisdiction of the Contracting Party of which they are nationals in respect of all acts or omissions occurring while they are in Antarctica for the purpose of exercising their functions.

2. Without prejudice to the provisions of paragraph 1 of this Article, and pending the adoption of measures in pursuance of subparagraph 1(e) of Article IX, the Contracting Parties concerned in any case of dispute with regard to the exercise of jurisdiction in Antarctica shall immediately consult together with a view to reaching a mutually acceptable solution.

ARTICLE IX

1. Representatives of the Contracting Parties named in the preamble to the present Treaty shall meet at the City of Canberra within two months after the date of entry into force of the Treaty, and thereafter at suitable intervals and places, for the purpose of exchanging information, consulting together on matters of common interest pertaining to Antarctica, and formulating and considering, and recommending to their Governments, measures in furtherance of the principles and objectives of the Treaty, including measures regarding:

a. use of Antarctica for peaceful purposes only;
b. facilitation of scientific research in Antarctica;
c. facilitation of international scientific cooperation in Antarctica;
d. facilitation of the exercise of the rights of inspection provided for in Article VII of the Treaty;
e. questions relating to the exercise of jurisdiction in Antarctica;
f. preservation and conservation of living resources in Antarctica.

2. Each Contracting Party which has become a party to the present Treaty by accession under Article XIII shall be entitled to appoint representatives to participate in the meetings referred to in paragraph 1 of the present Article, during such times as that Contracting Party demonstrates its interest in Antarctica by conducting substantial research activity there, such as the establishment of a scientific station or the despatch of a scientific expedition.

3. Reports from the observers referred to in Article VII of the present Treaty shall be transmitted to the representatives of the Contracting Parties participating in the meetings referred to in paragraph 1 of the present Article.

4. The measures referred to in paragraph 1 of this Article shall become effective when approved by all the Contracting Parties whose representatives were entitled to participate in the meetings held to consider those measures.

5. Any or all of the rights established in the present Treaty may be exercised as from the date of entry into force of the Treaty whether or not any measures facilitating the exercise of such rights have been proposed, considered or approved as provided in this Article.

ARTICLE X

Each of the Contracting Parties undertakes to exert appropriate efforts, consistent with the Charter of the United Nations, to the end that no one engages in any activity in Antarctica contrary to the principles or purposes of the present Treaty.

ARTICLE XI

1. If any dispute arises between two or more of the Contracting Parties concerning the interpretation or application of the present Treaty, those Contracting Parties shall consult among themselves with a view to having the

dispute resolved by negotiation, inquiry, mediation, conciliation, arbitration, judicial settlement or other peaceful means of their own choice.

2. Any dispute of this character not so resolved shall, with the consent, in each case, of all parties to the dispute, be referred to the International Court of Justice for settlement; but failure to reach agreement on reference to the International Court shall not absolve parties to the dispute from the responsibility of continuing to seek to resolve it by any of the various peaceful means referred to in paragraph 1 of this Article.

ARTICLE XII

1.

a. The present Treaty may be modified or amended at any time by unanimous agreement of the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article IX. Any such modification or amendment shall enter into force when the depositary Government has received notice from all such Contracting Parties that they have ratified it.

b. Such modification or amendment shall thereafter enter into force as to any other Contracting Party when notice of ratification by it has been received by the depositary Government. Any such Contracting Party from which no notice of ratification is received within a period of two years from the date of entry into force of the modification or amendment in accordance with the provision of subparagraph 1(a) of this Article shall be deemed to have withdrawn from the present Treaty on the date of the expiration of such period.

2.

a. If after the expiration of thirty years from the date of entry into force of the present Treaty, any of the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article IX so requests by a communication addressed to the depositary Government, a Conference of all the Contracting Parties shall be held as soon as practicable to review the operation of the Treaty.

b. Any modification or amendment to the present Treaty which is approved at such a Conference by a majority of the Contracting Parties there represented, including a majority of those whose representatives are entitled to participate in the meetings provided for under Article IX, shall be communicated by the depositary Government to all Contracting Parties immediately after the termination of the Conference and shall enter into force in accordance with the provisions of paragraph 1 of the present Article

c. If any such modification or amendment has not entered into force in accordance with the provisions of subparagraph 1(a) of this Article within a period of two years after the date of its communication to all the Contracting Parties,any Contracting Party may at any time after the expiration of that period give notice to the depositary Government of its withdrawal from the present Treaty; and such withdrawal shall take effect two years after the receipt of the notice by the depositary Government.

ARTICLE XIII

1. The present Treaty shall be subject to ratification by the signatory States. It shall be open for accession by any State which is a Member of the United Nations, or by any other State which may be invited to accede to the Treaty with the consent of all the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article IX of the Treaty.

2. Ratification of or accession to the present Treaty shall be effected by each State in accordance with its constitutional processes.

3. Instruments of ratification and instruments of accession shall be deposited with the Government of the United States of America, hereby designated as the depositary Government.

4. The depositary Government shall inform all signatory and acceding States of the date of each deposit of an instrument of ratification or accession, and the date of entry into force of the Treaty and of any modification or amendment thereto.

5. Upon the deposit of instruments of ratification by all the signatory States, the present Treaty shall enter into force for those States and for States which have deposited instruments of accession. Thereafter the Treaty shall enter into force for any acceding State upon the deposit of its instruments of accession.

6. The present Treaty shall be registered by the depositary Government pursuant to Article 102 of the Charter of the United Nations.

ARTICLE XIV

The present Treaty, done in the English, French, Russian and Spanish languages, each version being equally authentic, shall be deposited in the archives of the Government of the United States of America, which shall transmit duly certified copies thereof to the Governments of the signatory and acceding States.

Atomic Energy Act of 1946

A BILL

For the development and control of atomic energy

Be it enacted by the Senate and House of Representatives of the United States of America in congress assembled,

DECLARATION OF POLICY

Section 1. (a) Findings and Declaration. Research and experimentation in the field of nuclear fission have attained the stage at which the release of atomic energy on a large scale is practical. The significance of the atomic bomb for military purposes is evident. The effect of the use of atomic energy for civilian purposes upon the social, economic, and political structures of today cannot now be determined. It is reasonable to anticipate, however, that tapping this new source of energy will cause profound changes in our present way of life. Accordingly, it is hereby declared to be the policy of the people of the United States that the development and utilization of atomic energy shall be directed toward improving the public welfare, increasing the standard of living, strengthening free competition among private enterprises so far as practicable, and cementing world peace.

(b) Purpose of Act. It is the purpose of this Act to effectuate these policies by providing, among others, for the following major programs;

(1) A program of assisting and fostering private research and development on a truly independent basis to encourage maximum scientific progress;

(2) A program for the free dissemination of basic scientific information and for maximum liberality in dissemination of related technical information;

(3) A program of federally conducted research to assure the Government of adequate scientific and technical accomplishments;

(4) A program for Government control of the production, ownership, and use of fissionable materials to protect the national security and to insure the broadest possible exploitation of the field;

(5) A program for simultaneous study of the social, political, and economic effects of the utilization of atomic energy; and

(6) A program of administration which will be consistent with international agreements made by the United States, and which will enable the Congress to be currently informed so as to take further legislative action as may hereafter be appropriate.

ATOMIC ENERGY COMMISSION

See. 2. (a) There is hereby established an Atomic Energy Commission (herein called the Commission), which shall be composed of five members. Three members shall constitute a quorum of the Commission. The President shall designate one member as a Chairman of the Commission.

(b) Members of the Commission shall be appointed by the President, by and with the advice and consent of the Senate, and shall serve at the pleasure of the President. In submitting nominations to the Senate, the President shall set forth the experience and qualifications of each person so nominated. Each member, except the Chairman, shall receive com-pensation at the rate of $15,000 per annum; the Chairman shall receive compensation at the rate of 920.000 per annum. No member of the Commission shall engage in any other business, vocation, or employment than that of serving as a member of the Commission.

(c) The principal office of the Commission shall be in the District of Co-lumbia, but the Commission may exercise any or all of its powers in any place. The Commission shall hold such meetings, conduct such hearings, and receive such reports as will enable it to meet its responsibilities for carrying out the purpose of this Act.

RESEARCH

See. 3. (a) Research Assistance. The Commission is directed to exercise its powers in such a manner as to insure the continued conduct of research and developmental activities in the fields specified below by private or public institutions or persons and to assist in the acquisition of an ever-expanding fund of theoretical and practical knowledge in such fields. To this end the Commission is authorized and directed to make contracts, agreements, arrangements, grants-in-aid, and loans

(1) for the conduct of research and developmental activities relating to (a) nuclear processes; (b) the theory and production of atomic energy, including processes and devices related to such production; (c) utilization of fissionable and radioactive materials for medical or health purposes; (d) utilization of fissionable and radioactive materials for all other purposes, including industrial uses; and (e) the protection of health during research and production activities; and

(2) for studies of the social, political, and economic effects of the availability and utilization of atomic energy.

The Commission may make partial advance payments on such contracts and arrangements. Such contracts or other arrangements may contain provisions to protect health, to minimize danger from explosion, and for reporting and inspection of work performed thereunder as the Commission may deter-mine, but shall not contain any provisions or conditions which prevent the dissemination of scientific or technical information, except to the extent al-ready required by the Espionage Act.

(b) Federal Atomic Research. The Commission is authorized and directed to conduct research and developmental activities through its own fa-cilities in the fields specified in (a) above.

PRODUCTION OF FISSIONABLE MATERIALS

Sec. 4. (a) Definition. The term "production of fissionable materials" shall include all methods of manufacturing, producing, refining, or processing fissionable materials, including the process of separating fissionable material from other substances in which such material may be contained, whether by thermal diffusion, electromagnetic separation, or other processes.

(b) Authority to Produce. The Commission shall be the exclusive pro-ducer of fissionable materials, except production incident to research or de-velopmental activities subject to restrictions provided in subparagraph (d) below. The quantities of fissionable material to be produced in any quarter shall be determined by the President.

(c) Prohibition. It shall be unlawful for any person to produce any fissionable material except as may be incident to the conduct of research or developmental activities.

(d) Research and Development on Production Processes. (1) The Commission shall establish by regulation such requirements for the reporting of research and developmental activities on the production of fissionable materials as will assure the Commission of full knowledge of all such activities, rates of production, and quantities produced.

(2) The Commission shall provide for the frequent inspection of all such activities by employees of the Commission.

(3) No person may in the course of such research or developmental activities possess or operate facilities for the production of fissionable material in quantities or at a rate sufficient to construct a bomb or other military weapon unless all such facilities are the property of and subject to the control of the Commission. The Commission is authorized, to the extent that it deems such action consistent with the purposes of this Act, to enter into contracts for the conduct of such research or developmental activities involving the use of the Commission's facilities.

(e) Existing Contracts. The Commission is authorized to continue in effect and modify such contracts for the production of fissionable materials as may have been made prior to the effective date of this Act, except that, as rapidly as practicable, and in any event not more than one year after the effective date of this Act, the Commission shall arrange for the exclusive operation of facilities employed in the manufacture of fissionable materials by employees of the Commission.

CONTROL OF MATERIALS

See. 5. (a)(1) Definition. The term "fissionable materials" shall include plutonium, uranium 235, and such other materials as the Commission may from time to time determine to be capable of releasing substantial quantities of energy through nuclear fission of the materials.

(2) Privately Owned Fissionable Materials. Any person owning any right, title, or interest in or to any fissionable material shall forthwith transfer all such right, title, or interest to the Commission.

(3) Prohibition. It shall be unlawful for any person to (a) own any fissionable material; or (b) after sixty days after the effective date of this Act and except as authorized by the Commission possess any fissionable material; or (c) export from or import into the United States any fissionable material, or directly or indirectly be a party to or in any way a beneficiary of, any contract, arrangement or other activity pertaining to the production, refining, or processing of any fissionable material outside of the United States.

(4) Distribution of Fissionable Materials. The Commission is autho-rized and directed to distribute fissionable materials to all applicants requesting such materials for the conduct of research or developmental activities either independently or under contract or other arrange-

ment with the Commission. If sufficient materials are not available to meet all such requests, and applications for licenses under section 7, the Commission shall allocate fissionable materials among all such applicants in the manner best calculated to encourage independent research and development by making adequate fissionable materials available for such purposes. The Commission shall refuse to distribute or allocate any materials to any applicant, or shall recall any materials after distribution or allocation from any applicant, who is not equipped or who fails to observe such safety standards to protect health and to minimize danger from explosion as may be established by the Commission.

(b) Source Materials.

(1) Definition. The term "source materials" shall include any ore con-taining uranium, thorium, or beryllium, and such other materials peculiarly essential to the production of fissionable materials as may be determined by the Commission with the approval of the President.

(2) License for Transfers Required. No person may transfer possession or title to any source material after mining, extraction, or removal from its place of origin, and no person may receive any source material without a license from the Commission.

(3) Issuance of Licenses. Any person desiring to transfer or receive pos-session of any source material shall apply for a license therefor in accordance with such procedures as the Commission may by regulation establish. The Commission shall establish such standards for the issuance or refusal of licenses as it may deem necessary to assure adequate source materials for production, research or developmental activities pursuant to this Act or to prevent the use of such materials in a manner inconsistent with the national welfare.

(4) Reporting. The Commission is authorized to issue such regulations or orders requiring reports of ownership, possession, extraction, refining, shipment or other handling of source materials as it may deem necessary.

(c) Byproduct Materials

(1) Definition. The term "byproduct material" shall be deemed to refer to all materials (except fissionable material) yielded in the processes of producing fissionable material.

(2) Distribution. The Commission is authorized and directed to distribute, with or without charge, byproduct materials to all applicants seeking such materials for research or developmental work, medical therapy, industrial uses, or such other useful applications as may be developed. if sufficient materials to meet all such requests are not available, the Commission shall allocate such materials among applicants therefor, giving preference to the use of such materials in the conduct of research and developmental activity and medical therapy. The Commission shall refuse to distribute or allocate any byproduct materials to any applicant, or recall any materials after distribution or allocation from any applicant, who is not equipped or who fails to observe such safety standards to protect health as may be established by the Commission.

(d) General Provisions. (1) The Commission is authorized to

(i) acquire or purchase fissionable or source materials within the United States or elsewhere;

(ii) take, requisition, or condemn within the United States any fissionable or source material and make just compensation therefore. The Commission shall determine such compensation. In the exercise of such rights of eminent domain and condemnation, proceedings may be instituted under the Act of August 1, 1888 (U. S. C. 1940, title 40, sec. 257), or any other applicable Federal statute. Upon or after the filing of the condemnation petition, immediate possession may be taken and the property may be treated by the Commission in the same manner as other similar property owned by it;

(iii) conduct exploratory operation, investigations, inspections to determine the location, extent, mode of occurrence, use, or condition of source materials with or without the consent of the owner of any interest therein, making just compensation for any damage or injury occasioned thereby.

(2) The Commission shall establish by regulation a procedure by which any person who is dissatisfied with its action in allocating, refusing to allocate

or in rescinding any allocation of fissionable, source, or byproduct materials to him may obtain a review of such determination by a board of appeal con-sisting of two or more members appointed by the Commission and at least one member of the Commission.

MILITARY APPLICATIONS OF ATOMIC POWER

See. 6. (a) The Commission is authorized and directed to

(1) conduct experiments and do research and developmental work in the military application of atomic power; and

(2) have custody of all assembled or unassembled atomic bombs, bomb parts, or other atomic military weapons, presently or hereafter produced, except that upon the express finding of the President that such action is required in the interests of national defense, the Commission shall deliver such quantities of weapons to the armed forces as the President may specify.

(b) The Commission shall not conduct any research or developmental work in the military application of atomic power if such research or developmental work is contrary to any international agreement of the United States.

(e) The Commission is authorized to engage in the production of atomic bombs, bomb parts, or other applications of atomic power as military weapons, only to the extent that the express consent and direction of the President of the United States has been obtained, which consent and direction shall be obtained for each quarter.

(d) It shall be unlawful for any person to manufacture, produce, or process any device or equipment designed to utilize fissionable materials as a military weapon, except as authorized by the Commission.

ATOMIC ENERGY DEVICES

Sec. 7. (a) License Required.-It shall be unlawful for any person to operate any equipment or device utilizing fissionable materials without a license issued by the Commission authorizing such operation.

Issuance of Licenses.-Any person desiring to utilize fissionable materials in any such device or equipment shall apply for a license therefor in accordance with such procedures as the Commission may by regulation establish. The Commission is authorized and directed to issue such a license on a nonexclusive basis and to supply appropriate quantities of fissionable materials to the extent available to any applicant (1) who is equipped to observe such safety standards to protect health and to minimize danger from explosion as the Commission may establish; and (2) who agrees to make available to the Commission such technical information and data concerning the operation of such device as the Commission may determine necessary to encourage the use of such devices by as many licensees as possible. Where any license might serve to maintain or foster the growth of monopoly, restraint of trade, unlawful competition, or other trade position inimical to the entry of new, freely competitive enterprises, the Commission is authorized and directed to refuse to issue such license or to establish such conditions to prevent these results as the Commission, in consultation with the Attorney General, may determine. The Commission shall report promptly to the At-torney General any information it may have of the use of such devices which appears to have these results. No license may be given to a foreign govern-ment or to any person who is not under and within the jurisdiction of the United States.

(c) Byproduct Power. If in the production of fissionable materials the production processes yield energy capable of utilization, such energy may be used by the Commission, transferred to other Government agencies, sold to public or private utilities under contract providing for reasonable resale prices, or sold to private consumers at reasonable rates and on as broad a basis of eligibility as the Commission may determine to be possible.

(d) Reports to Congress. Whenever in its opinion industrial, commer-cial, or other uses of fissionable materials have been sufficiently developed to be of practical value, the Commission shall prepare a report to the Con-gress stating all the facts, the Commission's estimate of the social, political, and economic effects of such utilization, and the Commission's recommendations for necessary or desirable supplemental legislation. Until such a re-port has been filed with the Commission and the period of ninety days has elapsed after such filing within which period the Commission may adopt supplemental legislation, no license for the use of atomic energy devices shall be issued by the Commission.

PROPERTY OF THE COMMISSION

Sec. 8. (a) The President shall direct the transfer to the Commission of the following property owned by the United States or any of its agencies, or any interest in such property held in trust for or on behalf of the United States:

(1) All fissionable materials; all bombs and bomb parts; all plants, facili-ties, equipment, and materials for the processing or production of fissionable materials, bombs, and bomb parts; all processes and technical information of any kind, and the source thereof (including data, drawings, specifications, patents, patent applications, and other sources, relating to the refining or production of fissionable materials; and all contracts, agreements, leases, patents, applications for patents, inventions and discoveries (whether pat-ented or unpatented), and other rights of any kind concerning any such items;

(2) All facilities and equipment, and materials therein, devoted primarily to atomic energy research and development; and

(3) All property in the custody and control of the Manhattan engineer district.

(b) In order to render financial assistance to those States and local gov-ernments in which the activities of the Commission are carried on and in which the Commission, or its agents, have acquired properties previously subject to State and local taxation, the Commission is authorized to make payments to State and local governments in lieu of such taxes. Such payments may be in the amounts, at the times, and upon the terms the Commission deems appropriate, but the Commission shall be guided by the policy of not exceeding the taxes which would have been payable for such property in the condition in which it was acquired, except where special burdens have been cast upon the State or local government by activities of the Commission, the Manhattan engineer district, or their agents, and in such cases any benefits accruing to the States and local governments by reason of these activities shall be considered in the determination of such pay-ments. The Commission and any corporation created by it, and the property and income of the Commission or of such corporation, are hereby expressly exempted from taxation in any manner or form by any State, county, municipality, or any subdivision thereof.

DISSEMINATION OF INFORMATION

See. 9. (a) Basic Scientific Information. Basic scientific information in the fields specified in section 3 may be freely disseminated. The term "basic scientific information" shall include, in addition to theoretical knowledge of nuclear and other physics, chemistry, biology, and therapy, all results ca-pable of accomplishment, as distinguished from the processes or techniques of accomplishing them.

(b) Related Technical Information. The Commission shall establish a Board of Commission. The Board shall, under

the direction and supervision of the Commission, provide for the dissemination of related technical information with the utmost liberality as freely as may be consistent with the foreign and domestic policies established by the President and shall have authority to

(1) establish such information services, publications, libraries, and other registers of available information as may be helpful in effectuating this policy;

(2) designate by regulation the types of related technical information the dissemination of which will effectuate the foregoing policy. Such designations shall constitute an administrative determination that such information is not of value to the national defense and that any person is entitled to receive such information, within the meaning of the Espionage Act. Failure to make any such designation shall not, however, be deemed a determination that such undesignated information is subject to the provisions of said Act;

(3) by regulation or order, require reports of the conduct of independent research or development activities in the fields specified in sec-tion 3 and of the operation of atomic energy devices under licenses issued pursuant to section 7;

(4) provide for such inspections of independent research and devel-opment activities of the types specified in section 3 and of the operation of atomic energy devices as the Commission or the Board may deter-mine; and

(5) whenever it will facilitate the carrying out of the purposes of the Act, adopt by regulation administrative interpretations of the Espionage Act except that any such interpretation shall, before adoption, receive the express approval of the President.

PATENTS

See. 10. (a) Whenever any person invents a device or method for the production, refining, or processing of fissionable material: (i) he may file a patent application to cover such invention, sending a copy thereof to the Commission; (ii) if the Commissioner of Patents determines that the inven-tion is patentable, he shall issue a patent in the name of the Commission; and (iii) the Commission shall make just compensation to such person. The Commission shall appoint a Patent Royalty Board consisting of one or more employees and at least one member of the Commission, and the Commis-sioner of Patents. The Patent Royalty Board shall determine what constitutes just compensation in each such case and whether such compensation is to be paid in periodic payments rather than in a lump sum. Any person to whom any such patent has heretofore been issued shall forthwith transfer all right, title, and interest in and to such patent to the Commission and shall receive therefor just compensation as provided above.

(b) (1) Any patent now or hereafter issued covering any process or device utilizing or peculiarly necessary to the utilization of fissionable materials, or peculiarly necessary to the conduct of research or developmental activities in the fields specified in section 3, is hereby declared to be affected with the public interest and its general availability for such uses is declared to be necessary to affectuate the purposes of this Act.

(2) Any person to whom any such patent has been issued, or any person desiring to use any device or process covered by such patent for such uses, may apply to the Patent Royalty Board, for determination by such Board of a reasonable royalty fee for such use of the patented process or device in-tended to be used under the Commission's license.

(3) In determining such reasonable royalty fee, the Patent Royalty Board shall take into consideration any defense, general or special, that might be pleaded by a defendant in an action for infringement, the extent to which, if any, such patent was developed through federally financed research, the degree of utility, novelty, and importance of the patent, the cost to the pat-entee of developing such process or device, and a reasonable rate of return on such research investment by the patentee.

(4) No court, Federal, State, or Territorial, shall have jurisdiction or power to stay, restrain, or otherwise enjoin any such use of any such pat-ented device or process by any person on the ground of infringement of such patent. In any action for infringement of any such patent filed in any such court, the court shall have authority only to order the payment of reasonable royalty fees and attorney's fees and court costs as damages for any such in-fringement. If the Patent Royalty Board has not previously determined the reasonable royalty fee for the use of the patented device or process involved in any case, the court in such case shall, before entering judgment, obtain from the Patent Royalty Board a report containing its recommendation as to the reasonable royalty fee it would have established had application been made to it as provided in subparagraphs 2 and 3 above.

ORGANIZATIONAL AND GENERAL AUTHORITY

See. 11. (a) Organization. There are hereby established within the Commission a Division of Research, a Division of Production, a Division of Materials, and a Division of Military Application. Each division shall be under the direction of a Directory who shall be appointed by the President, by and with the advice and consent of the Senate, and shall receive compen-sation at the rate of $15,000 per annum. The Commission shall delegate to each such division such of its powers under this Act as in its opinion from time to time will promote the effectuation of the purposes of this Act in an efficient manner. Nothing in this paragraph shall prevent the Commission from establishing such additional divisions or other subordinate organiza-tions as it may deem desirable.

(b) General Authority.-In the performance of its functions the Commis-sion is authorized to-

(1) establish advisory boards to advise with and make recommen-dations to the Commission on legislation, policies, administration, and research;

(2) establish by regulation or order such standards and instructions to govern the possession and use of fissionable and byproduct materials as the Commission may deem necessary or desirable to protect health or to minimize danger from explosion;

(3) make such studies and investigations, obtain such information, and hold such hearings as the Commission may deem necessary or proper to assist it in exercising any authority provided in this Act, or in the admin-istration or enforcement of this Act, or any regulations or orders issued thereunder. For such purposes the Commission is authorized to require any person to permit the inspection and copying of any records or other documents, to administer oaths and affirmations, and by subpena to re-quire any person to appear and testify, or to appear and produce docu-ments, or both, at any designated place. Witnesses subpenaed under this subsection shall be paid the same fees and mileage as are paid witnesses in the district courts of the United States;

(4) create or organize corporations, the stock of which shall be wholly owned by the United States and controlled by the Commission, to carry out the provisions of this Act;

(5) appoint and fix the compensation of such officers and employees as may be necessary to carry out the functions of the Commission. All such officers and employees shall be appointed in accordance with the civil service laws and their compensation fixed in accordance with the Clas-sification Act of 1923, as amended, except that expert administrative, technical, and professional personnel may be employed and their com-pensation fixed without regard to such laws. The Commission shall make adequate provision for administrative review by a board consisting of one or more employees and at least one member of the Commission of any determination to dismiss any scientific or professional employee; and

(6) acquire such materials, property, equipment, and facilities, estab-lish or construct such buildings and facilities, modify such building and facilities from time to time, and construct, acquire, provide, or arrange for such facilities and services for the housing, health, safety, welfare, and recreation of personnel employed by the Commission as it may deem necessary.

ENFORCEMENT

See. 12. (a) Any person who willfully violates, attempts to violate, or con-spires to violate, any of the provisions of this Act or any regulations or orders issued thereunder shall, upon conviction thereof, be punishable by a fine of not more than $10,000, or by imprisonment for a term of not exceeding five years, or both.

(b) Whenever in the judgment of the commission any person has engaged or is about to engage in any acts or practices which constitute or will consti-tute a violation of any provision of this Act, it may make application to the appropriate court for an order enjoining such acts or practices, or for an order enforcing compliance with such provision, and upon a showing by the Commission that such person has engaged or is about to engage in any such acts or practices a permanent or temporary injunction, restraining order, or other order shall be granted without bond.

(c) In case of contumacy by, or refusal to obey a subpena served upon, any person pursuant to section 11 (b)

(3), the district court for any district in which such person is found or resides or transacts business, upon application by the Commission, shall have jurisdiction to issue an order requiring such person to appear and give testimony or to appear and produce documents, or both; and any failure to obey such order of the court may be punished by such court as a contempt thereof.

REPORTS

Sec. 13. The Commission shall, on the first days of January, April, July, and October, submit reports to the President, to the Senate and to the House of Representatives. Such reports shall summarize and appraise the ac-tivities of the Commission and of each division and board thereof, and specifically shall contain financial statements; lists of licenses issued, of property acquired, of research contracts and arrangements entered into, and of the amounts of fissionable material and the persons to whom allocated; the Com-mission's program for the following quarter including lists of research con-tracts and arrangements proposed to be entered into; conclusions drawn from studies of the social, political, and economic effects of the release of atomic energy; and such recommendations for additional legislation as the Commission may deem necessary or desirable.

DEFINITIONS

See. 14. As used in this Act-

(a) The term "atomic energy" shall include all forms of energy liberated in the artificial transmutation of atomic species.

(b) The term "Government agency" means any executive department, board, bureau, commission, or other agency in the executive branch of the Federal Government, or any corporation wholly owned (either directly or through one or more corporations) by the United States.

(c) The term "person" means any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, any gov-ernment other than the United States, any political subdivision of any such government, and any legal successor, representative, agent, or agency of the foregoing, or other entity.

(d) The term "United States" includes all Territories and possessions of the United States.

APPROPRIATIONS

Sec. 15. There are hereby authorized to be appropriated such sums as may be necessary and appropriate to carry out the provisions and purposes of this Act. Funds appropriated to the Commission shall, if obligated during the fiscal year for which appropriated, remain available for expenditure for four years following the expiration of the fiscal year for which appropriated. After such four-year period, the unexpended balances of appropriations shall be carried to the surplus fund and covered into the Treasury.

SEPARABILITY OF PROVISIONS

Sec. 16. If any provision of this Act, or the application of such provision to any person or circumstances, is held invalid, the remainder of this Act or the application of such provision to persons of circumstances other than those to which it is held invalid, shall not be affected thereby.

Agreement Between The United States of America and The Union of Soviet Socialist Republics on Notifications of Launches of Intercontinental Ballistic Missiles and Submarine-Launched Ballistic Missiles

Signed at Moscow May 31, 1988
Entered into Force May 31, 1988

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Affirming their desire to reduce and ultimately eliminate the risk of outbreak of nuclear war, in particular, as a result of misinterpretation, miscalculation, or accident,

Believing that a nuclear war cannot be won and must never be fought,

Believing that agreement on measures for reducing the risk of outbreak of nuclear war serves the interests of strengthening international peace and security,

Reaffirming their obligations under the Agreement on Measures to Reduce the Risk of Outbreak of Nuclear War between the United States of America and the Union of Soviet Socialist Republics of September 30, 1971, the Agreement between the Government of the United States of America and the Government of the Union of Soviet

Socialist Republics on the Prevention of Incidents on and over the High Seas of May 25, 1972, and the Agreement between the United States of America and the Union of Soviet Socialist Republics on the Establishment of Nuclear Risk Reduction Centers of September 15, 1987,

Have agreed as follows:

ARTICLE I

Each Party shall provide the other Party notification, through the Nuclear Risk Reduction Centers of the United States of America and the Union of Soviet Socialist Republics, no less than twenty-four hours in advance, of the planned date, launch area, and area of impact for any launch of a strategic ballistic missile: an intercontinental ballistic missile (hereinafter "ICBM") or a submarine-launched ballistic missile (hereinafter "SLBM").

ARTICLE II

A notification of a planned launch of an ICBM or an SLBM shall be valid for four days counting from the launch date indicated in such a notification. In case of postponement of the launch date within the indicated four days, or cancellation of the launch, no notification thereof shall be required.

ARTICLE III

1. For launches of ICBMs or SLBMs from land, the notification shall indicate the area from which the launch is planned to take place.
2. For launches of SLBMs from submarines, the notification shall indicate the general area from which the missile will be launched. Such notification shall indicate either the quadrant within the ocean (that is, the ninety-degree sector encompassing approximately one-fourth of the area of the ocean) or the body of water (for example, sea or bay) from which the launch is planned to take place.
3. For all launches of ICBMs or SLBMs, the notification shall indicate the geographic coordinates of the planned impact area or areas of the reentry vehicles. Such an area shall be specified either by indicating the geographic coordinates of the boundary points of the area, or by indicating the geographic coordinates of the center of a circle with a radius specified in kilometers or nautical miles. The size of the impact area shall be determined by the notifying Party at its discretion.

ARTICLE IV

The Parties undertake to hold consultations, as mutually agreed, to consider questions relating to implementation of the provisions of this Agreement, as well as to discuss possible amendments thereto aimed at furthering the implementation of the objectives of this Agreement. Amendments shall enter into force in accordance with procedures to be agreed upon.

ARTICLE V

This Agreement shall not affect the obligations of either Party under other agreements.

ARTICLE VI

This Agreement shall enter into force on the date of its signature.

The duration of this Agreement shall not be limited.

This Agreement may be terminated by either Party upon 12 months written notice to the other Party.

DONE at Moscow on May 31, 1988, in two copies, each in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES OF AMERICA:

George P. Shultz

FOR THE UNION OF SOVIET SOCIALIST REPUBLICS:

Eduard A. Shevardnadze

Convention on the Physical Protection of Nuclear Material

Signed at New York March 3, 1980
Ratification advised by U.S. Senate July 30, 1981
Ratified by U.S. President September 4, 1981
Entered into force February 8, 1987

The States Parties to This Convention,

Recognizing the right of all States to develop and apply nuclear energy for peaceful purposes and their legitimate interests in the potential benefits to be derived from the peaceful application of nuclear energy, Convinced of the need for facilitating international co-operation in the peaceful application of nuclear energy,

Desiring to avert the potential dangers posed by the unlawful taking and use of nuclear material,

Convinced that offenses relating to nuclear material are a matter of grave concern and that there is an urgent need to adopt appropriate and effective measures to ensure the prevention, detection and punishment of such offenses,

Aware of the Need for international co-operation to establish, in conformity with the national law of each State Party and with this Convention, effective measures for the physical protection of nuclear material,

Convinced that this Convention should facilitate the safe transfer of nuclear material,

Stressing also the importance of the physical protection of nuclear material in domestic use, storage and transport,

Recognizing the importance of effective physical protection of nuclear material used for military purposes, and understanding that such material is and will continue to be accorded stringent physical protection,

Have Agreed as follows:

ARTICLE 1

For the purposes of this Convention:

(a) "nuclear material" means plutonium except that with isotopic concentration exceeding 80% in plutonium-238; uranium-233; uranium enriched in the isotopes 235 or 233; uranium containing the mixture of isotopes as occurring in nature other than in the form of ore or ore-residue; any material containing one or more of the foregoing;

(b) "uranium enriched in the isotopes 235 or 233" means uranium containing the isotopes 235 or 233 or both in an amount such that the abundance ratio of the sum of these isotopes to the isotope 238 is greater than the ratio of the isotope 235 to the isotope 238 occurring in nature;

(c) "international nuclear transport" means the carriage of a consignment of nuclear material by any means of transportation intended to go beyond the territory of the State where the shipment originates beginning with the departure from a facility of the shipper in that State and ending with the arrival at a facility of the receiver within the State of ultimate destination.

ARTICLE 2

1. The Convention shall apply to nuclear material used for peaceful purposes while in international nuclear transport.

2. With the exception of articles 3 and 4 and paragraph 3 of article 5, this Convention shall also apply to nuclear material used for peaceful purposes while in domestic use, storage and transport.

3. Apart from the commitments expressly undertaken by States Parties in the articles covered by paragraph 2 with respect to nuclear material used for peaceful purposes while in domestic use, storage and transport, nothing in this Convention shall be interpreted as affecting the sovereign rights of a State regarding the domestic use, storage and transport of such nuclear material.

ARTICLE 3

Each State Party shall take appropriate steps within the framework of its national law and consistent with international law to ensure as far as practicable that, during international nuclear transport, nuclear material within its territory, or on board a ship or aircraft under its jurisdiction insofar as such ship or aircraft is engaged in the transport to or from that State, is protected at the levels described in Annex I.

ARTICLE 4

1. Each State Party shall not export or authorize the export of nuclear material unless the State Party has received assurances that such material will be protected during the international nuclear transport at the levels described in Annex I.

2. Each State Party shall not import or authorize the import of nuclear material from a State not party to this Convention unless the State Party has received assurances that such material will during the international nuclear transport be protected at the levels described in Annex I.

3. A State Party shall not allow the transit of its territory by land or internal waterways or through its airports or seaports of nuclear material between States that are not parties to this Convention unless the State Party has received assurances as far as practicable that this nuclear material will be protected during international nuclear transport at the levels described in Annex I.

4. Each State Party shall apply within the framework of its national law the levels of physical protection described in Annex I to nuclear material being transported

from a part of that State to another part of the same State through international waters or airspace.

5. The State Party responsible for receiving assurances that the nuclear material will be protected at the levels described in Annex I according to paragraphs 1 to 3 shall identify and inform in advance States which the nuclear material is expected to transit by land or internal waterways, or whose airports or seaports it is expected to enter.

6. The responsibility for obtaining assurances referred to in paragraph 1 may be transferred, by mutual agreement, to the State Party involved in the transport as the importing State.

7. Nothing in this article shall be interpreted as in any way affecting the territorial sovereignty and jurisdiction of a State, including that over its airspace and territorial sea.

ARTICLE 5

1. States Parties shall identify and make known to each other directly or through the International Atomic Energy Agency their central authority and point of contact having responsibility for physical protection of nuclear material and for coordinating recovery and response operations in the event of any unauthorized removal, use or alteration of nuclear material or in the event of credible threat thereof.

2. In the case of theft, robbery or any other unlawful taking of nuclear material or of credible threat thereof, States Parties shall, in accordance with their national law, provide co-operation and assistance to the maximum feasible extent in the recovery and protection of such material to any State that so requests. In particular:

(a) a State Party shall take appropriate steps to inform as soon as possible other States, which appear to it to be concerned, of any theft, robbery or other unlawful taking of nuclear material or credible threat thereof and to inform, where appropriate, international organizations;
(b) as appropriate, the States Parties concerned shall exchange information with each other or international organizations with a view to protecting threatened nuclear material, verifying the integrity of the shipping container, or recovering unlawfully taken nuclear material and shall:

(i) co-ordinate their efforts through diplomatic and other agreed channels;
(ii) render assistance, if requested;
(iii) ensure the return of nuclear material stolen or missing as a consequence of the above-mentioned events.

The means of implementation of this co-operation shall be determined by the States Parties concerned.

3. States Parties shall co-operate and consult as appropriate, with each other directly or through international organizations, with a view to obtaining guidance on the design, maintenance and improvement of systems of physical protection of nuclear material in international transport.

ARTICLE 6

1. States Parties shall take appropriate measures consistent with their national law to protect the confidentiality of any information which they receive in confidence by virtue of the provisions of this Convention from another State Party or through participation in an activity carried out for the implementation of this Convention. If States Parties provide information to international organizations in confidence, steps shall be taken to ensure that the confidentiality of such information is protected.

2. States Parties shall not be required by this Convention to provide any information which they are not permitted to communicate pursuant to national law or which would jeopardize the security of the State concerned or the physical protection of nuclear material.

ARTICLE 7

1. The intentional commission of:

(a) an act without lawful authority which constitutes the receipt, possession, use, transfer, alteration, disposal or dispersal of nuclear material and which causes or is likely to cause death or serious injury to any person or substantial damage to property;
(b) a theft or robbery of nuclear material;
(c) an embezzlement or fraudulent obtaining of nuclear material;
(d) an act constituting a demand for nuclear material by threat or use of force or by any other form of intimidation;
(e) a threat:
(i) to use nuclear material to cause death or serious injury to any person or substantial property damage, or
(ii) to commit an offense described in subparagraph (b) in order to compel a natural or legal person, international organization or State to do or to refrain from doing any act;
(f) an attempt to commit any offense described in paragraphs (a), (b) or (c); and

(g) an act which constitutes participation in any offense described in paragraphs (a) to (f) shall be made a punishable offense by each State Party under its national law.

2. Each State Party shall make the offenses described in this article punishable by appropriate penalties which take into account their grave nature.

ARTICLE 8

1. Each State Party shall take such measures as may be necessary to establish its jurisdiction over the offenses set forth in article 7 in the following cases:

(a) when the offense is committed in the territory of that State or on board a ship or aircraft registered in that State;
(b) when the alleged offender is a national of that State.

2. Each State Party shall likewise take such measures as may be necessary to establish its jurisdiction over these offenses in cases where the alleged offender is present in its territory and it does not extradite him pursuant to article 11 to any of the States mentioned in paragraph 1.

3. This Convention does not exclude any criminal jurisdiction exercised in accordance with national law.

4. In addition to the State Parties mentioned in paragraphs 1 and 2, each State Party may, consistent with international law, establish its jurisdiction over the offenses set forth in article 7 when it is involved in international nuclear transport as the exporting or importing State.

ARTICLE 9

Upon being satisfied that the circumstances so warrant, the State Party in whose territory the alleged offender is present shall take appropriate measures, including detention, under its national law to ensure his presence for the purpose of prosecution or extradition. Measures taken according to this article shall be notified without delay to the States required to establish jurisdiction pursuant to article 8 and, where appropriate, all other States concerned.

ARTICLE 10

The State Party in whose territory the alleged offender is present shall, if it does not extradite him, submit, without exception whatsoever and without undue delay, the case to its competent authorities for the purpose of prosecution, through proceedings in accordance with the laws of that State.

ARTICLE 11

1. The offenses in article 7 shall be deemed to be included as extraditable offenses in any extradition Treaty existing between States Parties. States Parties undertake to include those offenses as extraditable offenses in every future extradition Treaty to be concluded between them.

2. If a State Party which makes extradition conditional on the existence of a Treaty receives a request for extradition from another State Party with which it has no extradition Treaty, it may at its option consider this Convention as the legal basis for extradition in respect of those offenses. Extradition shall be subject to the other conditions provided by the law of the requested State.

3. State Parties which do not make extradition conditional on the existence of a Treaty shall recognize those offenses as extraditable offenses between themselves subject to the conditions provided by the law of the requested State.

4. Each of the offenses shall be treated, for the purpose of extradition between States Parties, as if it had been committed not only in the place in which it occurred but also in the territories of the State Parties required to establish their jurisdiction in accordance with paragraph 1 of article 8.

ARTICLE 12

Any person regarding whom proceedings are being carried out in connection with any of the offenses set forth in article 7 shall be guaranteed fair treatment at all stages of the proceedings.

ARTICLE 13

1. States Parties shall afford one another the greatest measure of assistance in connection with criminal proceedings brought in respect of the offenses set forth in article 7, including the supply of evidence at their disposal necessary for the proceedings. The law of the State requested shall apply in all cases.

2. The provisions of paragraph 1 shall not affect obligations under any other Treaty, bilateral or multilateral, which governs or will govern, in whole or in part, mutual assistance in criminal matters.

ARTICLE 14

1. Each State Party shall inform the depositary of its laws and regulations which give effect to this Convention. The depositary shall communicate such information periodically to all States Parties.

2. The State Party where an alleged offender is prosecuted shall, wherever practicable, first communicate the final outcome of the proceedings to the States directly concerned. The State Party shall also communicate the final outcome to the depositary who shall inform all States.

3. Where an offense involves nuclear material used for peaceful purposes in domestic use, storage or transport, and both the alleged offender and the nuclear material remain in the territory of the State Party in which the offense was committed, nothing in this Convention shall be interpreted as requiring that State Party to provide information concerning criminal proceedings arising out of such an offense.

ARTICLE 15

The Annexes constitute an integral part of this Convention.

ARTICLE 16

1. A conference of States Parties shall be convened by the depositary five years after the entry into force of this Convention to review the implementation of the Convention and its adequacy as concerns the preamble, the whole of the operative part and the annexes in the light of the then prevailing situation.

2. At intervals of not less than five years thereafter, the majority of States Parties may obtain, by submitting a proposal to this effect to the depositary, the convening of further conferences with the same objective.

ARTICLE 17

1. In the event of a dispute between two or more States Parties concerning the interpretation or application of this Convention, such States Parties shall consult with a view to the settlement of the dispute by negotiation, or by any other peaceful means of settling disputes acceptable to all parties to the dispute.

2. Any dispute of this character which cannot be settled in the manner prescribed in paragraph 1 shall, at the request of any party to such dispute, be submitted to arbitration or referred to the International Court of Justice for decision. Where a dispute is submitted to arbitration, if, within six months from the date of the request, the parties to the dispute are unable to agree on the organization of the arbitration, a party may request the President of the International Court of Justice or the Secretary-General of the United Nations to appoint one or more arbitrators. In case of conflicting requests by the parties to the dispute, the request to the Secretary-General of the United Nations shall have priority.

3. Each State Party may at the time of signature, ratification, acceptance or approval of this Convention or accession thereto declare that it does not consider itself bound by either or both of the dispute settlement procedures provided for in paragraph 2. The other States Parties shall not be bound by a dispute settlement procedure provided for in paragraph 2, with respect to a State Party which has made a reservation to that procedure.

4. Any State Party which has made a reservation in accordance with paragraph 3 may at any time withdraw that reservation by notification to the depositary.

ARTICLE 18

1. This Convention shall be open for signature by all States at the Headquarters of the International Atomic Energy Agency in Vienna and at the Headquarters of the United Nations in New York from 3 March 1980 until its entry into force.

2. This Convention is subject to ratification, acceptance or approval by the signatory States.

3. After its entry into force, this Convention will be open for accession by all States.

4.

(a) This Convention shall be open for signature or accession by international organizations and regional organizations of an integration or other nature, provided that any such organization is constituted by sovereign States and has competence in respect of the negotiation, conclusion and application of international agreements in matters covered by this Convention.

(b) In matters within their competence, such organizations shall, on their own behalf, exercise the rights and fulfill the responsibilities which this Convention attributes to States Parties.

(c) When becoming party to this Convention such an organization shall communicate to the depositary a declaration indicating which States are members thereof and which articles of this Convention do not apply to it.

(d) Such an organization shall not hold any vote additional to those of its Member States.

5. Instruments of ratification, acceptance, approval or accession shall be deposited with the depositary.

ARTICLE 19

1. This Convention shall enter into force on the thirtieth day following the date of deposit of the twenty-first instrument of ratification, acceptance or approval with the depositary.

2. For each State ratifying, accepting, approving or acceding to the Convention after the date of deposit of the twenty-first instrument of ratification, acceptance or approval, the Convention shall enter into force on the thirtieth day after the deposit by such State of its instrument of ratification, acceptance, approval or accession.

ARTICLE 20

1. Without prejudice to article 16 a State Party may propose amendments to this Convention. The proposed amendment shall be submitted to the depositary who shall circulate it immediately to all States Parties. If a majority of States Parties request the depositary to convene a conference to consider the proposed amendments, the depositary shall invite all States Parties to attend such a conference to begin not sooner than thirty days after the invitations are issued. Any amendment adopted at the conference by a two-thirds majority of all States Parties shall be promptly circulated by the depositary to all States Parties.

2. The amendment shall enter into force for each State Party that deposits its instrument of ratification, acceptance or approval of the amendment on the thirtieth day after the date on which two thirds of the States Parties have deposited their instruments of ratification, acceptance or approval with the depositary. Thereafter, the amendment shall enter into force for any other State Party on the day on which that State Party deposits its instrument of ratification, acceptance or approval of the amendment.

ARTICLE 21

1. Any State Party may denounce this Convention by written notification to the depositary.

2. Denunciation shall take effect one hundred and eighty days following the date on which notification is received by the depositary.

ARTICLE 22

The depositary shall promptly notify all States of:

(a) each signature of this Convention;
(b) each deposit of an instrument of ratification, acceptance, approval or accession;
(c) any reservation or withdrawal in accordance with article 17;
(d) any communication made by an organization in accordance with paragraph 4(c) of article 18;
(e) the entry into force of this Convention;
(f) the entry into force of any amendment to this Convention; and
(g) any denunciation made under article 21.

ARTICLE 23

The original of this Convention, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Director General of the International Atomic Energy Agency who shall send certified copies thereof to all States.

The G8 Global Partnership Against the Spread of Weapons and Materials of Mass Destruction

Statement by the Group of Eight Leaders
Kananaskis, Canada
June 27, 2002

The attacks of September 11 demonstrated that terrorists are prepared to use any means to cause terror and inflict appalling casualties on innocent people. We commit ourselves to prevent terrorists, or those that harbour them, from acquiring or developing nuclear, chemical, radiological and biological weapons; missiles; and related materials, equipment and technology. We call on all countries to join us in adopting the set of non-proliferation principles we have announced today.

In a major initiative to implement those principles, we have also decided today to launch a new G8 Global Partnership against the Spread of Weapons and Materials of Mass Destruction. Under this initiative, we will support specific cooperation projects, initially in Russia, to address non-proliferation, disarmament, counter-terrorism and nuclear safety issues. Among our priority concerns are the destruction of chemical weapons, the dismantlement of decommissioned nuclear submarines, the disposition of fissile materials and the employment of former weapons scientists. We will commit to raise up to $20 billion to support such projects over the next ten years. A range of financing options, including the option of bilateral debt for program exchanges, will be available to countries that contribute to this Global Partnership. We have adopted a set of guidelines that will form the basis for the negotiation of specific agreements for new projects, that will apply with immediate effect, to ensure effective and efficient project development, coordination and implementation. We will review over the next year the applicability of the guidelines to existing projects.

Recognizing that this Global Partnership will enhance international security and safety, we invite other countries that are prepared to adopt its common principles and guidelines to enter into discussions with us on participating in and contributing to this initiative. We will review progress on this Global Partnership at our next Summit in 2003.

THE G8 GLOBAL PARTNERSHIP: PRINCIPLES TO PREVENT TERRORISTS, OR THOSE THAT HARBOUR THEM, FROM GAINING ACCESS TO WEAPONS OR MATERIALS OF MASS DESTRUCTION

The G8 calls on all countries to join them in commitment to the following six principles to prevent terrorists or those that harbour them from acquiring or developing nuclear, chemical, radiological and biological weapons; missiles; and related materials, equipment and technology.

1. Promote the adoption, universalization, full implementation and, where necessary, strengthening of multilateral treaties and other international instruments whose aim is to prevent the proliferation or illicit acquisition of such items; strengthen the institutions designed to implement these instruments.
2. Develop and maintain appropriate effective measures to account for and secure such items in production, use, storage and domestic and international transport; provide assistance to states lacking sufficient resources to account for and secure these items.
3. Develop and maintain appropriate effective physical protection measures applied to facilities which house such items, including defence in depth; provide assistance to states lacking sufficient resources to protect their facilities.
4. Develop and maintain effective border controls, law enforcement efforts and international cooperation to detect, deter and interdict in cases of illicit trafficking in such items, for example through installation of detection systems, training of customs and law enforcement personnel and cooperation in tracking these items; provide assistance to states lacking sufficient expertise or resources to strengthen their capacity to detect, deter and interdict in cases of illicit trafficking in these items.
5. Develop, review and maintain effective national export and transshipment controls over items on multilateral export control lists, as well as items that are not identified on such lists but which may nevertheless contribute to the development, production or use of nuclear, chemical and biological weapons and missiles, with particular consideration of end-user, catch-all and brokering aspects; provide assistance to states lacking the legal and regulatory infrastructure, implementation experience and/or resources to develop their export and transshipment control systems in this regard.
6. Adopt and strengthen efforts to manage and dispose of stocks of fissile materials designated as no longer required for defence purposes, eliminate all chemical weapons, and minimize holdings of dangerous biological pathogens and toxins, based on the recognition that the threat of terrorist acquisition is reduced as the overall quantity of such items is reduced.

THE G8 GLOBAL PARTNERSHIP: GUIDELINES FOR NEW OR EXPANDED COOPERATION PROJECTS

The G8 will work in partnership, bilaterally and multilaterally, to develop, coordinate, implement and finance, according to their respective means, new or expanded cooperation projects to address (i) non-proliferation, (ii) disarmament, (iii) counter-terrorism and (iv) nuclear safety (including environmental) issues, with a view to enhancing strategic stability, consonant with our international security objectives and in support of the multilateral non-proliferation regimes. Each country has primary responsibility for implementing its non-proliferation, disarmament, counter-terrorism and nuclear safety obligations and requirements and commits its full cooperation within the Partnership.

Cooperation projects under this initiative will be decided and implemented, taking into account international obligations and domestic laws of participating partners, within appropriate bilateral and multilateral legal frameworks that should, as necessary, include the following elements:

1. Mutually agreed effective monitoring, auditing and transparency measures and procedures will be required in order to ensure that cooperative activities meet agreed objectives (including irreversibility as necessary), to confirm work performance, to account for the funds expended and to provide for adequate access for donor representatives to work sites;
2. The projects will be implemented in an environmentally sound manner and will maintain the highest appropriate level of safety;
3. Clearly defined milestones will be developed for each project, including the option of suspending or terminating a project if the milestones are not met;
4. The material, equipment, technology, services and expertise provided will be solely for peaceful purposes and, unless otherwise agreed, will be used only for the purposes of implementing the projects and will not be transferred. Adequate measures of physical protection will also be applied to prevent theft or sabotage;
5. All governments will take necessary steps to ensure that the support provided will be considered free technical assistance and will be exempt from taxes, duties, levies and other charges;
6. Procurement of goods and services will be conducted in accordance with open international practices to the extent possible, consistent with national security requirements;
7. All governments will take necessary steps to ensure that adequate liability protections from claims related to the cooperation will be provided for donor countries and their personnel and contractors;
8. Appropriate privileges and immunities will be provided for government donor representatives working on cooperation projects; and
9. Measures will be put in place to ensure effective protection of sensitive information and intellectual property.

Given the breadth and scope of the activities to be undertaken, the G8 will establish an appropriate mechanism for the annual review of progress under this initiative which may include consultations regarding priorities, identification of project gaps and potential overlap, and assessment of consistency of the cooperation projects with international security obligations and objectives. Specific bilateral and multilateral project implementation will be coordinated subject to arrangements appropriate to that project, including existing mechanisms.

For the purposes of these guidelines, the phrase “new or expanded cooperation projects” is defined as cooperation projects that will be initiated or enhanced on the basis of this Global Partnership. All funds disbursed or released after its announcement would be included in the total of committed resources. A range of financing options, including the option of bilateral debt for program exchanges, will be available to countries that contribute to this Global Partnership.

The Global Partnership’s initial geographic focus will be on projects in Russia, which maintains primary responsibility for implementing its obligations and requirements within the Partnership.

In addition, the G8 would be willing to enter into negotiations with any other recipient countries, including those of the Former Soviet Union, prepared to adopt the guidelines, for inclusion in the Partnership.

Recognizing that the Global Partnership is designed to enhance international security and safety, the G8 invites others to contribute to and join in this initiative.

With respect to nuclear safety and security, the partners agreed to establish a new G8 Nuclear Safety and Security Group by the time of our next Summit.

Harmel Report and NATO Dual-Track Decision (1979)

At a special meeting of Foreign and Defence Ministers in Brussels on 12th December 1979:

Ministers recalled the May 1978 Summit where governments expressed the political resolve to meet the challenges to their security posed by the continuing momentum of the Warsaw Pact military build-up.

The Warsaw Pact has over the years developed a large and growing capability in nuclear systems that directly threaten Western Europe and have a strategic significance for the Alliance in Europe. This situation has been especially aggravated over the last few years by Soviet decisions to implement programmes modernizing and expanding their long-range nuclear capability substantially. In particular, they have deployed the SS-20 missile, which offers significant improvements over previous systems in providing greater accuracy, more mobility, and greater range, as well as having multiple warheads, and the Backfire bomber, which has a much better performance than other Soviet aircraft deployed hitherto in a theatre role. During this period, while the Soviet Union has been reinforcing its superiority in Long Range Theatre Nuclear Forces (LRTNF) both quantitatively and qualitatively, Western LRTNF capabilities have remained static. Indeed these forces are increasing in age and vulnerability and do not include land-based, long-range theatre nuclear missile systems

At the same time, the Soviets have also undertaken a modernization and expansion of their shorter-range TNF and greatly improved the overall quality of their conventional forces. These developments took place against the background of increasing Soviet inter-continental capabilities and achievement of parity in inter-continental capability with the United States.

These trends have prompted serious concern within the Alliance, because, if they were to continue, Soviet superiority in theatre nuclear systems could undermine the stability achieved in inter-continental systems and cast doubt on the credibility of the Alliance's deterrent strategy by highlighting the gap in the spectrum of NATO's available nuclear response to aggression.

Ministers noted that these recent developments require concrete actions on the part of the Alliance if NATO's strategy of flexible response is to remain credible. After intensive consideration, including the merits of alternative approaches, and after taking note of the positions of certain members, Ministers concluded that the overall interest of the Alliance would best be served by pursuing two parallel and complementary approaches of TNF modernization and arms control.

Accordingly Ministers have decided to modernize NATO's LRTNF by the deployment in Europe of US ground-launched systems comprising 108 Pershing II launchers, which would replace existing US Pershing I-A, and 464 Ground Launched Cruise Missiles (GLCM), all with single warheads. All the nations currently participating in the integrated defence structure will participate in the programme: the missiles will be stationed in selected countries and certain support costs will be met through NATO's existing common funding arrangements. The programme will not increase NATO's reliance upon nuclear weapons. In this connection, Ministers agreed that as an integral part of TNF modernization, 1.000 US nuclear warheads will be withdrawn from Europe as soon as feasible. Further, Ministers decided that the 572 LRTNF warheads should be accommodated within that reduced level, which necessarily implies a numerical shift of emphasis away from warheads for delivery systems of other types and shorter ranges In addition they noted with satisfaction that the Nuclear Planning Group is undertaking an examination of the precise nature, scope and basis of the adjustments resulting from the LRTNF deployment and their possible implications for the balance of roles and systems in NATO's nuclear armoury as a whole. This examination will form the basis of a substantive report to NPG Ministers in the Autumn of 1980.

Ministers attach great importance to the role of arms control in contributing to a more stable military relationship between East and West and in advancing the process of detente. This is reflected in a broad set of initiatives being examined within the Alliance to further the course of arms control and detente in the 1980s. Ministers regard arms control as an integral part of the Alliance's efforts to assure the undiminished security of its member States and to make the strategic situation between East and West more stable, more predictable, and more manageable at lower levels of armaments on both sides. In this regard they welcome the contribution which the SALT II Treaty makes towards achieving these objectives.

Ministers consider that, building on this accomplishment and taking account of the expansion of Soviet LRTNF capabilities of concern to NATO, arms control efforts to achieve a more stable overall nuclear balance at lower levels of nuclear weapons on both sides should therefore now include certain US and Soviet long-range theatre nuclear systems This would reflect previous Western suggestions to include such Soviet and US systems in arms control negotiations and more recent expressions by Soviet President Brezhnev of willingness to do so. Ministers fully support the decision taken by the United States following consultations within the Alliance to negotiate arms limitations on LRTNF and to propose to the USSR to begin negotiations as soon as possible along the following lines which have been elaborated in intensive consultations within the Alliance:

1. Any future limitations on US systems principally designed for theatre missions should be accompanied by appropriate limitations on Soviet theatre systems.
2. Limitations on US and Soviet long-range theatre nuclear systems should be negotiated bilaterally in the SALT III framework in a step-by-step approach.
3. The immediate objective of these negotiations should be the establishment of agreed limitations on US and Soviet land-based long-range theatre nuclear missile systems.
4. Any agreed limitations on these systems must be consistent with the principle of equality between the sides. Therefore, the limitations should take the form of de jure equality both in ceilings and in rights.

5. Any agreed limitations must be adequately verifiable.

Given the special importance of these negotiations for the overall security of the Alliance, a special consultative body at a high level will be constituted within the Alliance to support the US negotiating effort. This body will follow the negotiations on a continuous basis and report to the Foreign and Defence Ministers who will examine developments in these negotiations as well as in other arms control negotiations at their semi-annual meetings.

The Ministers have decided to pursue these two parallel and complementary approaches in order to avert an arms race in Europe caused by the Soviet TNF build-up, yet preserve the viability of NATO's strategy of deterrence and defence and thus maintain the security of its member States.

1. A modernization decision, including a commitment to deployments, is necessary to meet NATO's deterrence and defence needs, to provide a credible response to unilateral Soviet TNF deployments, and to provide the foundation for the pursuit of serious negotiations on TNF.
2. Success of arms control in constraining the Soviet build-up can enhance Alliance security, modify the scale of NATO's TNF requirements, and promote stability and detente in Europe in consonance with NATO's basic policy of deterrence, defence and detente as enunciated in the Harmel Report. NATO's TNF requirements will be examined in the light of concrete results reached through negotiations.

Footnote:
France did not participate in the Special Meeting.

THE FUTURE TASKS OF THE ALLIANCE (THE HARMEL REPORT): REPORT OF THE COUNCIL (DECEMBER 12, 1979)

A year ago, on the initiative of the Foreign Minister of Belgium, the governments of the fifteen nations of the Alliance resolved to *"study the future tasks which face the Alliance, and its procedures for fulfilling them in order to strengthen the Alliance as a factor for durable peace"*. The present report sets forth the general tenor and main principles emerging from this examination of the future tasks of the Alliance.

2. Studies were undertaken by Messrs. Schutz, Watson, Spaak, Kohler and Patijn. The Council wishes to express its appreciation and thanks to these eminent personalities for their efforts and for the analyses they produced.

3. The exercise has shown that the Alliance is a dynamic and vigorous organization which is constantly adapting itself to changing conditions. It also has shown that its future tasks can be handled within the terms of the Treaty by building on the methods and procedures which have proved their value over many years.

4. Since the North Atlantic Treaty was signed in 1949 the international situation has changed significantly and the political tasks of the Alliance have assumed a new dimension. Amongst other developments, the Alliance has played a major part in stopping Communist expansion in Europe; the USSR has become one of the two world super powers but the Communist world is no longer monolithic; the Soviet doctrine of *"peaceful co-existence"* has changed the nature of the confrontation with the West but not the basic problems. Although the disparity between the power of the United States and that of the European states remains, Europe has recovered and is on its way towards unity. The process of decolonisation has transformed European relations with the rest of the world; at the same time, major problems have arisen in the relations between developed and developing countries.

5. The Atlantic Alliance has two main functions. Its first function is to maintain adequate military strength and political solidarity to deter aggression and other forms of pressure and to defend the territory of member countries if aggression should occur. Since its inception, the Alliance has successfully fulfilled this task. But the possibility of a crisis cannot be excluded as long as the central political issues in Europe, first and foremost the German question, remain unsolved. Moreover, the situation of instability and uncertainty still precludes a balanced reduction of military forces. Under these conditions, the Allies will maintain as necessary, a suitable military capability to assure the balance of forces, thereby creating a climate of stability, security and confidence.

In this climate the Alliance can carry out its second function, to pursue the search for progress towards a more stable relationship in which the underlying political issues can be solved. Military security and a policy of détente are not contradictory but complementary. Collective defence is a stabilizing factor in world politics. It is the necessary condition for effective policies directed towards a greater relaxation of tensions. The way to peace and stability in Europe rests in particular on the use of the Alliance constructively in the interest of détente. The participation of the USSR and the USA will be necessary to achieve a settlement of the political problems in Europe.

6. From the beginning the Atlantic Alliance has been a co- operative grouping of states sharing the same ideals and with a high degree of common interest. Their cohe-

sion and solidarity provide an element of stability within the Atlantic area.

7. As sovereign states the Allies are not obliged to subordinate their policies to collective decision. The Alliance affords an effective forum and clearing house for the exchange of information and views; thus, each of the Allies can decide its policy in the light of close knowledge of the problems and objectives of the others. To this end the practice of frank and timely consultations needs to be deepened and improved. Each Ally should play its full part in promoting an improvement in relations with the Soviet Union and the countries of Eastern Europe, bearing in mind that the pursuit of détente must not be allowed to split the Alliance. The chances of success will clearly be greatest if the Allies remain on parallel courses, especially in matters of close concern to them all; their actions will thus be all the more effective.

8. No peaceful order in Europe is possible without a major effort by all concerned. The evolution of Soviet and East European policies gives ground for hope that those governments may eventually come to recognize the advantages to them of collaborating in working towards a peaceful settlement. But no final and stable settlement in Europe is possible without a solution of the German question which lies at the heart of present tensions in Europe. Any such settlement must end the unnatural barriers between Eastern and Western Europe, which are most clearly and cruelly manifested in the division of Germany.

9. Accordingly the Allies are resolved to direct their energies to this purpose by realistic measures designed to further a détente in East-West relations. The relaxation of tensions is not the final goal but is part of a long-term process to promote better relations and to foster a European settlement. The ultimate political purpose of the Alliance is to achieve a just and lasting peaceful order in Europe accompanied by appropriate security guarantees.

10. Currently, the development of contacts between the countries of Western and Eastern Europe is mainly on a bilateral basis. Certain subjects, of course, require by their very nature a multilateral solution.

11. The problem of German reunification and its relationship to a European settlement has normally been dealt with in exchanges between the Soviet Union and the three Western powers having special responsibilities in this field. In the preparation of such exchanges the Federal Republic of Germany has regularly joined the three Western powers in order to reach a common position. The other Allies will continue to have their views considered in timely discussions among the Allies about Western policy on this subject, without in any way impairing the special responsibilities in question.

12. The Allies will examine and review suitable policies designed to achieve a just and stable order in Europe, to overcome the division of Germany and to foster European security. This will be part of a process of active and constant preparation for the time when fruitful discussions of these complex questions may be possible bilaterally or multilaterally between Eastern and Western nations.

13. The Allies are studying disarmament and practical arm control measures, including the possibility of balanced force reductions. These studies will be intensified. Their active pursuit reflects the will of the Allies to work for an effective détente with the East.

14. The Allies will examine with particular attention the defence problems of the exposed areas e.g. the South-Eastern flank. In this respect the present situation in the Mediterranean presents special problems, bearing in mind that the current crisis in the Middle East falls within the responsibilities of the United Nations.

15. The North Atlantic Treaty area cannot be treated in isolation from the rest of the world. Crises and conflicts arising outside the area may impair its security either directly or by affecting the global balance. Allied countries contribute individually within the United Nations and other international organizations to the maintenance of international peace and security and to the solution of important international problems. In accordance with established usage the Allies or such of them as wish to do so will also continue to consult on such problems without commitment and as the case may demand.

16. In the light of these findings, the Ministers directed the Council in permanent session to carry out, in the years ahead, the detailed follow-up resulting from this study. This will be done either b intensifying work already in hand or by activating highly specialized studies by more systematic use of experts and officials sent from capitals.

17. Ministers found that the study by the Special Group confirmed the importance of the role which the Alliance is called upon to play during the coming years in the promotion of détente and the strengthening of peace. Since significant problems have not yet bee] examined in all their aspects, and other problems of no less significance which have arisen from the latest political and strategic developments have still to be examined, the Ministers have directed the Permanent Representatives to put in hand the study of these problems without delay, following such procedures as shall be deemed most appropriate by the Council in permanent session, in order to enable further reports to be subsequently submitted to the Council in Ministerial Session.

SPECIAL MEETING OF FOREIGN AND DEFENCE MINISTERS (THE "DOUBLE-TRACK" DECISION ON THEATRE NUCLEAR FORCES)

Brussels, 12 December 1979

1. At a special meeting of Foreign and Defence Ministers in

Brussels on 12 December 1979.

2. Ministers recalled the May 1978 Summit where governments expressed the political resolve to meet the challenges to their security posed by the continuing momentum of the Warsaw Pact military build-up.

3. The Warsaw Pact has over the years developed a large and growing capability in nuclear systems that directly threaten Western Europe and have a strategic significance for the Alliance in Europe. This situation has been especially aggravated over the last few years by Soviet decisions to implement programmes modernising and expanding their long-range nuclear capability substantially. In particular, they have deployed the SS-20 missile, which offers significant improvements over previous systems in providing greater accuracy, more mobility, and greater range, as well as having multiple warheads, and the Backfire bomber, which has a much better performance than other Soviet aircraft deployed hitherto in a theatre role.

During this period, while the Soviet Union has been reinforcing its superiority in Long-Range Theatre Nuclear Forces (LRTNF) both quantitatively and qualitatively, Western LRTNF capabilities have remained static. Indeed these forces are increasing in age and vulnerability and do not include land-based, long-range theatre nuclear missile systems.

4. At the same time, the Soviets have also undertaken a modernisation and expansion of their shorter-range TNF and greatly improved the overall quality of their conventional forces.

These developments took place against the background of increasing Soviet inter-continental capabilities and achievement of parity in inter-continental capability with the United States.

5. These trends have prompted serious concern within the Alliance, because, if they were to continue, Soviet superiority in theatre nuclear systems could undermine the stability achieved in inter-continental systems and cast doubt on the credibility of the Alliance's deterrent strategy by highlighting the gap in the spectrum of NATO's available nuclear response to aggression.

6. Ministers noted that these recent developments require concrete actions on the part of the Alliance if NATO's strategy of flexible response is to remain credible. After intensive consideration, including the merits of alternative approaches, and after taking note of the positions of certain members, Ministers concluded that the overall interest of the Alliance would best be served by pursuing two parallel and complementary approaches of TNF modernisation and arms control.

7. Accordingly Ministers have decided to modernise NATO's LRTNF by the deployment in Europe of US ground-launched systems comprising 108 Pershing II launchers, which would replace existing US Pershing I-A, and 464 Ground-Launched Cruise Missiles (GLCM), all with single warheads. All the nations currently participating in the integrated defence structure will participate in the programme: the missiles will be stationed in selected countries and certain support costs will be met through NATO's existing common funding arrangements.

The programme will not increase NATO's reliance upon nuclear weapons. In this connection, Ministers agreed that as an integral part of TNF modernisation, 1,000 US nuclear warheads will be withdrawn from Europe as soon as feasible. Further, Ministers decided that the 572 LRTNF warheads should be accommodated within that reduced level, which necessarily implies a numerical shift of emphasis away from warheads for delivery systems of other types and shorter ranges In addition they noted with satisfaction that the Nuclear Planning Group is undertaking an examination of the precise nature, scope and basis of the adjustments resulting from the LRTNF deployment and their possible implications for the balance of roles and systems in NATO's nuclear armoury as a whole. This examination will form the basis of a substantive report to NPG Ministers in the Autumn of 1980.

8. Ministers attach great importance to the role of arms control in contributing to a more stable military relationship between East and West and in advancing the process of détente. This is reflected in a broad set of initiatives being examined within the Alliance to further the course of arms control and détente in the 1980s. Ministers regard arms control as an integral part of the Alliance's efforts to assure the undiminished security of its member States and to make the strategic situation between East and West more stable, more predictable, and more manageable at lower levels of armaments on both sides. In this regard they welcome the contribution which the SALT II Treaty makes towards achieving these objectives.

9. Ministers consider that, building on this accomplishment and taking account of the expansion of Soviet LRTNF capabilities of concern to NATO, arms control efforts to achieve a more stable overall nuclear balance at lower levels of nuclear weapons on both sides should therefore now include certain US and Soviet long-range theatre nuclear systems. This would reflect previous Western suggestions to include such Soviet and US systems in arms control negotiations and more recent expressions by Soviet President Brezhnev of willingness to do so. Ministers fully support the decision taken by the United States following consultations within the Alliance to negotiate arms limitations on LRTNF and to propose to the USSR to begin negotiations as soon as possible along the following lines which have been elaborated in intensive consultations within the Alliance:

a. Any future limitations on US systems principally designed for theatre missions should be accompanied by appropriate limitations on Soviet theatre systems.

b. Limitations on US and Soviet long-range theatre nuclear systems should be negotiated bilaterally in the SALT III framework in a step-by-step approach.

c. The immediate objective of these negotiations should be the establishment of agreed limitations on US and Soviet land-based long-range theatre nuclear missile systems.

d. Any agreed limitations on these systems must be consistent with the principle of equality between the sides. Therefore, the limitations should take the form of de jure equality both in ceilings and in rights.

e. Any agreed limitations must be adequately verifiable.

10. Given the special importance of these negotiations for the overall security of the Alliance, a special consultative body at a high level will be constituted within the Alliance to support the US negotiating effort. This body will follow the negotiations on a continuous basis and report to the Foreign and Defence Ministers who will examine developments in these negotiations as well as in other arms control negotiations at their semi-annual meetings.

11. The Ministers have decided to pursue these two parallel and complementary approaches in order to avert an arms race in Europe caused by the Soviet TNF buildup, yet preserve the viability of NATO's strategy of deterrence and defence and thus maintain the security of its member States.

a. A modernisation decision, including a commitment to deployments, is necessary to meet NATO's deterrence and defence needs, to provide a credible response to unilateral Soviet TNF deployments, and to provide the foundation for the pursuit of serious negotiations on TNF.

b. Success of arms control in constraining the Soviet buildup can enhance Alliance security, modify the scale of NATO's TNF requirements, and promote stability and détente in Europe in consonance with NATO's basic policy of deterrence, defence and détente as enunciated in the Harmel Report. NATO's TNF requirements will be examined in the light of concrete results reached through negotiations.

Hot Line Agreement (1963)

(DEPARTMENT OF STATE SUMMARY)

Bilateral agreement establishing a direct communications link between U.S. and Soviet heads of state for use in "time of emergency." Seeks to reduce the risk of a nuclear exchange stemming from accident, miscalculation, or surprise attack. Both sides connected by transatlantic cable and radio telegraph circuits for continuous direct communications. Updated in 1971 to include two U.S.-U.S.S.R. satellite communications circuits, along with multiple terminals in each country. The treaty entered into force on June 20, 1963.

NARRATIVE

The need for ensuring quick and reliable communication directly between the heads of government of nuclear-weapons states first emerged in the context of efforts to reduce the danger that accident, miscalculation, or surprise attack might trigger a nuclear war. These risks, arising out of conditions which are novel in history and peculiar to the nuclear-armed missile age, can of course threaten all countries, directly or indirectly.

The Soviet Union had been the first nation to propose, in 1954, specific safeguards against surprise attack; it also expressed concern about the danger of accidental war. At Western initiative, a Conference of Experts on Surprise Attack was held in Geneva in 1958, but recessed without achieving conclusive results, although it stimulated technical research on the issues involved.

In its "Program for General and Complete Disarmament in a Peaceful World," presented to the General Assembly by President Kennedy on September 25, 1961, the United States proposed a group of measures to reduce the risks of war. These included advance notification of military movements and maneuvers, observation posts at major transportation centers and air bases, and additional inspection arrangements. An international commission would be established to study possible further measures to reduce risks, including "failure of communication."

The United States draft Treaty outline submitted to the ENDC 1on April 18, 1962, added a proposal for the exchange of military missions to improve communications and understanding. It also proposed "establishment of rapid and reliable communications" among the heads of government and with the Secretary General of the United Nations.

The Soviet draft Treaty on general and complete disarmament (March 15, 1962) offered no provisions covering the risk of war by surprise attack, miscalculation, or accident. On July 16, however, the Soviet Union introduced amendments to its draft that called for (1) a ban on joint maneuvers involving the forces of two or more states and advance notification of substantial military movements, (2) exchange of military missions, and (3) improved communications between heads of government and with the U.N. Secretary General. These measures were not separable from the rest of the Soviet program.

The Cuban missile crisis of October 1962 compellingly underscored the importance of prompt, direct communication between heads of state. On December 12 of that year, a U.S. working paper submitted to the ENDC urged consideration of a number of measures to reduce the risk of war. These measures, the United States argued, offered opportunities for early agreement and could be undertaken either as a group or separately. Included was establishment of communications links between major capitals to ensure rapid and reliable communications in times of crisis. The working paper suggested that it did not appear either necessary or desirable to specify in advance all the situations in which a special communications link might be used:

. . . In the view of the United States, such a link should, as a general matter, be reserved for emergency use; that is to say, for example, that it might be reserved for communications concerning a military crisis which might appear directly to threaten the security of either of the states involved and where such developments were taking place at a rate which appeared to preclude the use of normal consultative procedures. Effectiveness of the link would not be degraded through use for other matters.

On June 20, 1963, at Geneva the U.S. and Soviet representatives to the ENDC completed negotiations and signed the "Memorandum of Understanding Between the United States of America and the Union of Soviet Socialist Republics Regarding the Establishment of a Direct Communications Link." The memorandum provided that each government should be responsible for arrangements for the link on its own territory, including continuous functioning of the link and prompt delivery of communications to its head of government. An annex set forth the routing and components of the link and provided for allocation of costs, exchange of equipment, and other technical matters. The direct communications link would comprise:

1. two terminal points with teletype equipment;
2. a full-time duplex wire telegraph circuit (Washington-London-Copenhagen-Stockholm-Helsinki-Moscow); and
3. a full-time duplex radiotelegraph circuit (Washington-Tangier-Moscow).

If the wire circuit should be interrupted, messages would be transmitted by the radio circuit. If experience showed the need for an additional wire circuit, it might be established by mutual agreement.

The "Hot Line" agreement, the first bilateral agreement between the United States and the Soviet Union that gave concrete recognition to the perils implicit in modern nuclear-weapons systems, was a limited but practical step to bring those perils under rational control.

The communications link has proved its worth since its installation. During the Arab-Israeli war in 1967, for example, the United States used it to prevent possible misunderstanding of U.S. fleet movements in the Mediterranean. It was used again during the 1973 Arab-Israeli war. The significance of the hot line is further attested by the 1971, 1984 and 1988 agreements to modernize it.

Statute of the International Atomic Energy Agency

(Excerpts)

Opened for signature at New York on 26 October 1956
Entered into force on 29 July 1957
Depositary: US government

ARTICLE II. *OBJECTIVES*

The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose.

ARTICLE III. *FUNCTIONS*

A. The Agency is authorized:

. . .

5. To establish and administer safeguards designed to ensure that special fissionable and other materials, services, equipment, facilities, and information made available by the Agency or at its request or under its supervision or control are not used in such a way as to further any military purpose; and to apply safeguards, at the request of the parties, to any bilateral or multilateral arrangement, or at the request of a State, to any of that State's activities in the field of atomic energy;

. . .

ARTICLE XII. *AGENCY SAFEGUARDS*

A. With respect to any Agency project, or other arrangement where the Agency is requested by the parties concerned to apply safeguards, the Agency shall have the following rights and responsibilities to the extent relevant to the project or arrangement:

72 ARMS CONTROL

1. To examine the design of specialized equipment and facilities, including nuclear reactors, and to approve it only from the view-point of assuring that it will not further any military purpose, that it complies with applicable health and safety standards, and that it will permit effective application of the safeguards provided for in this article;

2. To require the observance of any health and safety measures prescribed by the Agency;

3. To require the maintenance and production of operating records to assist in ensuring accountability for source and special fissionable materials used or produced in the project or arrangement;

4. To call for and receive progress reports;

5. To approve the means to be used for the chemical processing of irradiated materials solely to ensure that this chemical processing will not lend itself to diversion of materials for military purposes and will comply with applicable health and safety standards; to require that special fissionable materials recovered or produced as a by-product be used for peaceful purposes under continuing Agency safeguards for research or in reactors, existing or under construction, specified by the member or members concerned; and to require deposit with the Agency of any excess of any special fissionable materials recovered or produced as a by-product over what is needed for the above-stated uses in order to prevent stockpiling of these materials, provided that thereafter at the request of the member or members concerned special fissionable materials so deposited with the Agency shall be returned promptly to the member or members concerned for use under the same provisions as stated above;

6. To send into the territory of the recipient State or States inspectors, designated by the Agency after consultation with the State or States concerned, who shall have access at all times to all places and data and to any person who by reason of his occupation deals with materials, equipment, or facilities which are required by this Statute to be safeguarded, as necessary to account for source and special fissionable materials supplied and fissionable products and to determine whether there is compliance with the undertaking against use in furtherance of any military purpose referred to in sub-paragraph F-4 of article XI, with the health and safety measures referred to in sub-paragraph A-2 of this article, and with any other conditions prescribed in the agreement between the Agency and the State or States concerned. Inspectors designated by the Agency shall be accompanied by representatives of the authorities of the State concerned, if that State so requests, provided that the inspectors shall not thereby be delayed or otherwise impeded in the exercise of their functions;

7. In the event of non-compliance and failure by the recipient State or States to take requested corrective steps within a reasonable time, to suspend or terminate assistance and withdraw any materials and equipment made available by the Agency or a member in furtherance of the project.

B. The Agency shall, as necessary, establish a staff of inspectors. The Staff of inspectors shall have the responsibility of examining all operations conducted by the Agency itself to determine whether the Agency is complying with the health and safety measures prescribed by it for application to projects subject to its approval, supervision or control, and whether the Agency is taking adequate measures to prevent the source and special fissionable materials in its custody or used or produced

POST-WORLD WAR II AGREEMENTS 73

in its own operations from being used in furtherance of any military purpose. The Agency shall take remedial action forthwith to correct any non-compliance or failure to take adequate measures.

C. . . . The inspectors shall report any non-compliance to the Director General who shall thereupon transmit the report to the Board of Governors. The Board shall call upon the recipient State or States to remedy forthwith any non-compliance which it finds to have occurred. The Board shall report the non-compliance to all members and to the Security Council and General Assembly of the United Nations. In the event of failure of the recipient State or States to take fully corrective action within a reasonable time, the Board may take one or both of the following measures: direct curtailment or suspension of assistance being provided by the Agency or by a member, and call for the return of materials and equipment made available to the recipient member or group of members. The Agency may also, in accordance with article XIX, suspend any non-complying member from the exercise of the privileges and rights of membership.

. . .

ARTICLE XVIII. *AMENDMENTS AND WITHDRAWALS*

. . .

E. Withdrawal by a member from the Agency shall not affect its contractual obligations entered into pursuant to article XI or its budgetary obligations for the year in which it withdraws.

. . .

ARTICLE XX. *DEFINITIONS*

As used in this Statute:

1. The term "special fissionable material" means plutonium-239; uranium-233; uranium enriched in the isotopes 235 or 233; any material containing one or more of the foregoing; and such other fissionable material as the Board of Governors shall from time to time determine; but the term "special fissionable material" does not include source material.

2. The term "uranium enriched in the isotopes 235 or 233" means uranium containing the isotopes 235 or 233 or both in an amount such that the abundance ratio of the sum of these isotopes to the isotope 238 is greater than the ratio of the isotope 235 to the isotope 238 occurring in nature.

3. The term "source material" means uranium containing the mixture of isotopes occurring in nature, uranium depleted in the isotope 235; thorium; any of the foregoing in the form of metal, alloy, chemical compound, or concentrate; any other material containing one or more of the foregoing in such concentration as the Board of Governors shall from time to time determine; and such other material as the Board of Governors shall from time to time determine.

ARTICLE XXI. *SIGNATURE, ACCEPTANCE, AND ENTRY INTO FORCE*

. . .

B. The signatory States shall become parties to this Statute by deposit of an instrument of ratification.

. . .

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E. This Statute, apart from the Annex, shall come into force when eighteen States have deposited instruments of ratification in accordance with paragraph B of this article, provided that such eighteen States shall include at least three of the following States: Canada, France, the Union of Soviet Socialist Republics, the United Kingdom of Great Britain and Northern Ireland, and the United States of America. Instruments of ratification and instruments of acceptance deposited thereafter shall take effect on the date of their receipt.

. . .

Source: *Statute, as amended up to 28 December 1989* (International Atomic Energy

Agency: Vienna, June 1990)

Members of the IAEA as of 15 April 2002: Afghanistan, Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bangladesh, Belarus, Belgium, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Cambodia, Cameroon, Canada, Central African Republic, Chile, China, Colombia, Congo (Democratic Republic of), Costa Rica, Cote d'Ivoire, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Finland, France, Gabon, Georgia, Germany, Ghana, Greece, Guatemala, Haiti, Holy See, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea (South), Kuwait, Latvia, Lebanon, Liberia, Libya, Liechtenstein, Lithuania, Luxembourg, Macedonia (Former Yugoslav Republic of), Madagascar, Malaysia, Mali, Malta, Marshall Islands, Mauritius, Mexico, Moldova, Monaco, Mongolia, Morocco, Myanmar (Burma), Namibia, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Qatar,

Romania, Russia, Saudi Arabia, Senegal, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Syria, Tajikistan, Tanzania, Thailand, Tunisia, Turkey, Uganda, UK, Ukraine, United Arab Emirates, Uruguay, USA, Uzbekistan, Venezuela, Viet Nam, Yemen, Yugoslavia, Zambia, Zimbabwe

Note: North Korea was a member of the IAEA until September 1994.

Interim Agreement Between the United States of America and the Union of Soviet Socialist Republics on Certain Measures with Respect to the Limitation of Strategic Offensive Arms (SALT I)

Signed at Moscow May 26, 1972
Approval authorized by U.S. Congress September 30, 1972
Approved by U.S. President September 30, 1972
Entered into force October 3, 1972

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Convinced that the Treaty on the Limitation of Anti-Ballistic Missile Systems and this Interim Agreement on Certain Measures with Respect to the Limitation of Strategic Offensive Arms will contribute to the creation of more favorable conditions for active negotiations on limiting strategic arms as well as to the relaxation of international tension and the strengthening of trus between States, Taking into account the relationship between strategic offensive and defensive arms,

Mindful of their obligations under Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons,

Have agreed as follows:

ARTICLE I

The Parties undertake not to start construction of additional fixed land-based intercontinental ballistic missile (ICBM) launchers after July 1, 1972.

ARTICLE II

The Parties undertake not to convert land-based launchers for light ICBMs, or for ICBMs of older types deployed prior to 1964, into land-based launchers for heavy ICBMs of types deployed after that time.

ARTICLE III

The Parties undertake to limit submarine- launched ballistic missile (SLBM) launchers and modern ballistic missile submarines to the numbers operational and under construction on the date of signature of this Interim Agreement, and in addition to launchers and submarines constructed under procedures established by the Parties as replacements for an equal number of ICBM launchers of older types deployed prior to 1964 or for launchers on older submarines.

ARTICLE IV

Subject to the provisions of this Interim Agreement, modernization and replacement of strategicoffensive ballistic missiles and launchers covered by this Interim Agreement may be undertaken.

ARTICLE V

1. For the purpose of providing assurance of compliance with the provisions of this Interim Agreement, each Party shall use national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law.
2. Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph 1 of this Article.
3. Each Party undertakes not to use deliberate concealment measures which impede verification by national technical means of compliance with the provisions of this Interim Agreement. This obligation shall not require changes in current construction, assembly, conversion, or overhaul practices.

ARTICLE VI

To promote the objectives and implementation of the provisions of this Interim Agreement, the Parties shall use the Standing Consultative Commission established under Article XIII of theTreaty on the Limitation of Anti-Ballistic Missile Systems in accordance with the provisions of that Article.

ARTICLE VII

The Parties undertake to continue active negotiations for limitations on strategic offensive arms.The obligations provided for in this Interim Agreement shall not prejudice the scope or terms ofthe limitations on strategic offensive arms which may be worked out in the course of further negotiations.

ARTICLE VIII

1. This Interim Agreement shall enter into force upon exchange of written notices of acceptance by each Party, which exchange shall take place simultaneously with the exchange of instruments of ratification of the Treaty on the Limitation of Anti-Ballistic Missile Systems.
2. This Interim Agreement shall remain in force for a period of five years unless replaced earlier by an agreement on more complete measures limiting strategic offensive arms. It is the objective of the Parties to conduct active follow-on negotiations with the aim of concluding such an agreement as soon as possible.
3. Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Interim Agreement if it decides that extraordinary events related to the subject matter of this Interim Agreement have jeopardized its supreme interests. It shall give

notice of its decision to the other Party six months prior to withdrawal from this Interim Agreement. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests.

DONE at Moscow on May 26, 1972, in two copies, each in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES OF AMERICA:
RICHARD NIXON
President of the United States of America
FOR THE UNION OF SOVIET SOCIALIST REPUBLICS:
L.I. BREZHNEV
General Secretary of the
Central Committee of the CPSU

PROTOCOL TO THE INTERIM AGREEMENT

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Having agreed on certain limitations relating to submarine-launched ballistic missile launchers and modern ballistic missile submarines, and to replacement procedures, in the Interim Agreement,

Have agreed as follows:

The Parties understand that, under Article III of the Interim Agreement, for the period during which that Agreement remains in force:

The United States may have no more than 710 ballistic missile launchers on submarines (SLBMs) and no more than 44 modern ballistic missile submarines. The Soviet Union may have no more than 950 ballistic missile launchers on submarines and no more than 62 modern ballistic missile submarines.

Additional ballistic missile launchers on submarines up to the above-mentioned levels, in the United States — over 656 ballistic missile launchers on nuclear-powered submarines, and in the USSR — over 740 ballistic missile launchers on nuclear-powered submarines, operational and under construction, may become operational as replacements for equal numbers of ballistic missile launchers of older types deployed prior to 1964 or of ballistic missile launchers on older submarines.

The deployment of modern SLBMs on any submarine, regardless of type, will be counted against the total level of SLBMs permitted for the United States and the USSR.

This Protocol shall be considered an integral part of the Interim Agreement.

DONE at Moscow this 26th day of May, 1972
FOR THE UNITED STATES OF AMERICA:
RICHARD NIXON
President of the United States of America
FOR THE UNION OF SOVIET SOCIALIST REPUBLICS:
L.I. BREZHNEV
General Secretary of the
Central Committee of the CPSU

AGREED STATEMENTS, COMMON UNDERSTANDINGS, AND UNILATERAL STATEMENTS REGARDING THE INTERIM AGREEMENT

1. Agreed Statements

The document set forth below was agreed upon and initialed by the Heads of the Delegations on May 26, 1972 (letter designations added):

[A]

The Parties understand that land-based ICBM launchers referred to in the Interim Agreement are understood to be launchers for strategic ballistic missiles capable of ranges in excess of the shortest distance between the northeastern border of the continental United States and the northwestern border of the continental USSR.

[B]

The Parties understand that fixed land-based ICBM launchers under active construction as of the date of signature of the Interim Agreement may be completed.

[C]

The Parties understand that in the process of modernization and replacement the dimensions of land-based ICBM silo launchers will not be significantly increased.

[D]

The Parties understand that during the period of the Interim Agreement there shall be no significant increase in the number of ICBM or SLBM test and training launchers, or in the number of such launchers for modern land-based heavy ICBMs. The Parties further understand that construction or conversion of ICBM launchers at test ranges shall be undertaken only for purposes of testing and training.

[E]

The Parties understand that dismantling or destruction of ICBM launchers of older types deployed prior to 1964 and ballistic missile launchers on older submarines being replaced by newSLBM launchers on modern submarines will be initiated at the time of the beginning of sea trials of a replacement submarine, and will be completed in the shortest possible agreed period of time.Such dismantling or destruction, and timely notification thereof, will be accomplished under procedures to be agreed in the Standing Consultative Commission.

2. Common Understandings

Common understanding of the Parties on the following matters was reached during the negotiations:

A. Increase in ICBM Silo Dimensions

Ambassador Smith made the following statement on May 26, 1972:

The Parties agree that the term "significantly increased" means that an increase will not be greater than 10-15 percent of the present dimensions of land-based ICBM silo launchers.

Minister Semenov replied that this statement corresponded to the Soviet understanding.

B. Standing Consultative Commission

Ambassador Smith made the following statement on May 22, 1972:

The United States proposes that the sides agree that, with regard to initial implementation of the ABM Treaty's Article XIII on the Standing Consultative Commission (SCC) and of the consultation Articles to the Interim Agreement on offensive arms and the Accidents Agreement,

See Article 7 of Agreement to Reduce the Risk of the Outbreak of Nuclear War Between the United States of America and the Union of Soviet Socialist Republics, signed Sept. 30, 1971 agreement establishing the SCC will be worked out early in the follow-on SALT negotiations; until that is completed, the following arrangements will prevail: when SALT is in session, any consultation desired by either side under these Articles can be carried out by the two SALT Delegations; when SALT is not in session, *ad hoc* arrangements for any desired consultationsunder these Articles may be made through diplomatic channels.

Minister Semenov replied that, on an *ad referendum* basis, he could agree that the U.S. statement corresponded to the Soviet understanding.

C. Standstill

On May 6, 1972, Minister Semenov made the following statement:

In an effort to accommodate the wishes of the U.S. side, the Soviet Delegation is prepared to proceed on the basis that the two sides will in fact observe the obligations of both the Interim Agreement and the ABM Treaty beginning from the date of signature of these two documents.

In reply, the U.S. Delegation made the following statement on May 20, 1972:

The United States agrees in principle with the Soviet statement made on May 6 concerning observance of obligations beginning from date of signature but we would like to make clear our understanding that this means that, pending ratification and acceptance, neither side would take any action prohibited by the agreements after they had entered into force. This understanding would continue to apply in the absence of notification by either signatory of its intention not to proceed with ratification or approval.

The Soviet Delegation indicated agreement with the U.S. statement.

3. Unilateral Statements

(a) The following noteworthy unilateral statements were made during the negotiations by the United States Delegation:

A. Withdrawal from the ABM Treaty

On May 9, 1972, Ambassador Smith made the following statement:

The U.S. Delegation has stressed the importance the U.S. Government attaches to achieving agreement on more complete limitations on strategic offensive arms, following agreement on an ABM Treaty and on an Interim Agreement on certain measures with respect to the limitation of strategic offensive arms. The U.S. Delegation believes that an objective of the follow-on negotiations should be to constrain and reduce on a long-term basis threats to the survivability of our respective strategic retaliatory forces. The USSR Delegation has also indicated that the objectives of SALT would remain unfulfilled without the achievement of an agreement providing for more complete limitations on strategic offensive arms. Both sides recognize that the initial agreements would be steps toward the achievement of more complete limitations on strategic arms. If an agreement providing for more complete strategic offensive arms limitations were not achieved within five years, U.S. supreme interests could be jeopardized. Should that occur, itwould constitute a basis for withdrawal from the ABM Treaty. The United States does not wishto see such a situation occur, nor do we believe that the USSR does. It is because we wish to prevent such a situation that we emphasize the importance the U.S. Government attaches to achievement of more complete limitations on strategic offensive arms. The U.S. Executive will inform the Congress, in connection with Congressional consideration of the ABM Treaty and the Interim Agreement, of this statement of the U.S. position.

B. Land-Mobile ICBM Launchers

The U.S. Delegation made the following statement on May 20, 1972:

In connection with the important subject of land-mobile ICBM launchers, in the interest of concluding the Interim Agreement the U.S. Delegation now withdraws its proposal that Article Ior an agreed statement explicitly prohibit the deployment of mobile land-based ICBM launchers. I have been instructed to inform you that, while agreeing to defer the question of limitation of operational land-mobile ICBM launchers to the subsequent negotiations on more complete limitations on strategic offensive arms, the United States would consider the deployment of operational land-mobile ICBM launchers during the period of the Interim Agreement as inconsistent with the objectives of that Agreement.

C. Covered Facilities

The U.S. Delegation made the following statement on May 20, 1972:

I wish to emphasize the importance that the United States attaches to the provisions of Article V,including in particular their application to fitting out or berthing submarines.

D. "Heavy" ICBMs

The U.S. Delegation made the following statement on May 26, 1972:

The U.S. Delegation regrets that the Soviet Delegation has not been willing to agree on a common definition of a heavy missile. Under these circumstances, the U.S. Delegation believes it necessary to state the following: The United States would consider any ICBM having a volume significantly greater than that of the largest light ICBM now operational on either side to be a heavy ICBM. The United States proceeds on the premise that the Soviet side will give due account to this consideration.

On May 17, 1972, Minister Semenov made the following unilateral "Statement of the Soviet Side":

Taking into account that modern ballistic missile submarines are presently in the possession of not only the United States, but also of its NATO allies, the Soviet Union agrees that for the period of effectiveness of the Interim Freeze Agreement the United States and its NATO allies have up to 50 such submarines with a total of up to 800 ballistic missile launchers thereon (including 41 U.S. submarines with 656 ballistic missile launchers). However, if during the period of effectiveness of the Agreement U.S. allies in NATO should increase the number of their modern submarines to exceed the numbers of submarines they would have operational or under construction on the date of signature of the Agreement, the Soviet Union will have the right to a corresponding increase in the number of its submarines. In the opinion of the Soviet side, the solution of the question of modern ballistic missile submarines provided for in the Interim Agreement only partially compensates for the strategic imbalance in the deployment ofthe nuclear-powered missile submarines of the USSR and the United States. Therefore, the Soviet side believes that this whole question, and above all the question of liquidating the American missile submarine bases outside the United States, will be appropriately resolved in the course of follow-on negotiations.

On May 24, Ambassador Smith made the following reply to Minister Semenov:

The United States side has studied the "statement made by the Soviet side" of May 17 concerning compensation for submarine basing and SLBM submarines belonging to third countries. The United States does not accept the validity of the considerations in that statement.

On May 26 Minister Semenov repeated the unilateral statement made on May 17. Ambassador Smith also repeated the U.S. rejection on May 26.

Joint Declaration on the Denuclearization of the Korean Peninsula

Entry into force on February 19, 1992

South and North Korea,

In order to eliminate the danger of nuclear war through the denuclearization of the Korean peninsula, to create conditions and an environment favourable to peace and the peaceful unification of Korea, and thus to contribute to the peace and security of Asia and the world,

Declare as follows:

1. South and North Korea shall not test, manufacture, produce, receive, possess, store, deploy or use nuclear weapons.
2. South and North Korea shall use nuclear energy solely for peaceful purposes.
3. South and North Korea shall not possess nuclear reprocessing and uranium enrichment facilities.
4. In order to verify the denuclearization of the Korean peninsula, South and North Korea shall conduct inspections of particular subjects chosen by the other side and agreed upon between the two sides, in accordance with the procedures and methods to be determined by the South-North Joint Nuclear Control Commission.
5. In order to implement this joint declaration, South and North Korea shall establish and operate a South-North Joint Nuclear Control Commission within one month of the entry into force of this joint declaration;
6. This joint declaration shall enter into force from the date the South and the North exchange the appropriate instruments following the completion of their respective procedures for bringing it into effect.

Chung Won-shik, Chief Delegate of the South delegation to the South-North High-Level Negotiations, Prime Minister of the Republic of Korea

Yon Hyong-muk, Head of the North delegation to the South-North High-Level Negotiations, Premier of the Administration Council of the Democratic People's Republic of Korea

Missile Technology Control Regime

The United States Government has, after careful consideration and subject to its international treaty obligations, decided that, when considering the transfer of equipment and technology related to missiles, it will act in accordance with the attached Guidelines beginning on January 7, 1993. These Guidelines replace those adopted on April 16, 1987.

GUIDELINES FOR SENSITIVE MISSILE-RELEVANT TRANSFERS

1. The purpose of these Guidelines is to limit the risks of proliferation of weapons of mass destruction (i.e. nuclear, chemical and biological weapons), by controlling transfers that could make a contribution to delivery systems (other than manned aircraft) for such weapons. The Guidelines are not designed to impede national space programs or international cooperation in such programs as long as such programs could not contribute to delivery systems for weapons of mass destruction. These Guidelines, including the attached Annex, form the basis for controlling transfers to any destination beyond the Government's jurisdiction or control of all delivery systems (other than manned aircraft) capable of delivering weapons of mass destruction, and of equipment and technology relevant to missiles whose performance in terms of payload and range exceeds stated parameters. Restraint will be exercised in the consideration of all transfers of items contained within the Annex and all such transfers will be considered on a case-by-case basis. The Government will implement the Guidelines in accordance with national legislation.
2. The Annex consists of two categories of items, which term includes equipment and technology. Category I items, all of which are in Annex Items 1 and 2, are those items of greatest sensitivity. If a Category I item is included in a system, that system will also be considered as Category I, except when the incorporated item cannot be separated, removed or duplicated. Particular restraint will be exercised in the consideration of Category I transfers regardless of their purpose, and there will be a strong presumption to deny such transfers. Particular restraint will also be exercised in the consideration of transfers of any items in the Annex, or of any missiles (whether or not in the Annex), if the Government judges, on the basis of all available, persuasive information, evaluated according to factors including those in paragraph 3, that they are intended to be used for the delivery of weapons of mass destruction, and there will be a strong presumption to deny such transfers. Until further notice, the transfer of Category I production facilities will not be authorized. The transfer of other Category I items will be authorized only on rare occasions and where the Government (A) obtains binding government-to-government undertakings embodying the assurances from the recipient government called for in paragraph 5 of these Guidelines and (B) assumes responsibility for taking all steps necessary to ensure that the item is put only to its stated end-use. It is understood that the decision to transfer remains the sole and sovereign judgment of the United States Government.
3. In the evaluation of transfer applications for Annex items, the following factors will be taken into account:
   A. Concerns about the proliferation of weapons of mass destruction;
   B. The capabilities and objectives of the missile and space programs of the recipient state;
   C. The significance of the transfer in terms of the potential development of delivery systems (other than mannedaircraft) for weapons of mass destruction;
   D. The assessment of the end-use of the transfers, including the relevant assurances of the recipient states referred to in sub-paragraphs 5.A and 5.B below;

E. The applicability of relevant multilateral agreements.

4. The transfer of design and production technology directly associated with any items in the Annex will be subject to as great a degree of scrutiny and control as will the equipment itself, to the extent permitted by national legislation.
5. Where the transfer could contribute to a delivery system for weapons of mass destruction, the Government will authorize transfers of items in the Annex only on receipt of appropriate assurances from the government of the recipient state that:
A. The items will be used only for the purpose stated and that such use will not be modified nor the items modified or replicated without the prior consent of the United States Government;
B. Neither the items nor replicas nor derivatives thereof will be retransferred without the consent of the United States Government.
6. In furtherance of the effective operation of the Guidelines, the United States Government will, as necessary and appropriate, exchange relevant information with other governments applying the same Guidelines.
7. The adherence of all States to these Guidelines in the interest of international peace and security would be welcome.

[Annex to MTCR not included]

National Security Strategy of the United States of America

Executive Summary

September 2002

The great struggles of the twentieth century between liberty and totalitarianism ended with a decisive victory for the forces of freedom—and a single sustainable model for national success: freedom, democracy, and free enterprise. In the twenty-first century, only nations that share a commitment to protecting basic human rights and guaranteeing political and economic freedom will be able to unleash the potential of their people and assure their future prosperity.

People everywhere want to be able to speak freely; choose who will govern them; worship as they please; educate their children—male and female; own property; and enjoy the benefits of their labor. These values of freedom are right and true for every person, in every society—and the duty of protecting these values against their enemies is the common calling of freedom-loving people across the globe and across the ages.

Today, the United States enjoys a position of unparalleled military strength and great economic and political influence. In keeping with our heritage and principles, we do not use our strength to press for unilateral advantage.We seek instead to create a balance of power that favors human freedom: conditions in which all nations and all societies can choose for themselves the rewards and challenges of political and economic liberty. In a world that is safe, people will be able to make their own lives better.We will defend the peace by fighting terrorists and tyrants.We will preserve the peace by building good relations among the great powers. We will extend the peace by encouraging free and open societies on every continent.

Defending our Nation against its enemies is the first and fundamental commitment of the Federal Government. Today, that task has changed dramatically. Enemies in the past needed great armies and great industrial capabilities to endanger America. Now, shadowy networks of individuals can bring great chaos and suffering to our shores for less than it costs to purchase a single tank. Terrorists are organized to penetrate open societies and to turn the power of modern technologies against us.

To defeat this threat we must make use of every tool in our arsenal—military power, better homeland defenses, law enforcement, intelligence, and vigorous efforts to cut off terrorist financing. The war against terrorists of global reach is a global enterprise of uncertain duration. America will help nations that need our assistance in combating terror. And America will hold to account nations that are compromised by terror, including those who harbor terrorists—

because the allies of terror are the enemies of civilization. The United States and countries cooperating with us must not allow the terrorists to develop new home bases. Together, we will seek to deny them sanctuary at every turn.

The gravest danger our Nation faces lies at the crossroads of radicalism and technology. Our enemies have openly declared that they are seeking weapons of mass destruction, and evidence indicates that they are doing so with determination. The United States will not allow these efforts to succeed.We will build defenses against ballistic missiles and other means of delivery. We will cooperate with other nations to deny, contain, and curtail our enemies' efforts to acquire dangerous technologies. And, as a matter of common sense and self-defense, America will act against such emerging threats before they are fully formed. We cannot defend America and our friends by hoping for the best. So we must be prepared to defeat our enemies' plans, using the best intelligence and proceeding with deliberation. History will judge harshly those who saw this coming danger but failed to act. In the new world we have entered, the only path to peace and security is the path of action.

As we defend the peace, we will also take advantage of an historic opportunity to preserve the peace. Today, the international community has the best chance since the rise of the nation-state in the seventeenth century to build a world where great powers compete in peace instead of continually prepare for war. Today, the world's great powers find ourselves on the same side—united by common dangers of terrorist violence and chaos. The United States will build on these common interests to promote global security. We are also increasingly united by common values. Russia is in the midst of a hopeful transition, reaching for its democratic future and a partner in the war on terror. Chinese leaders are discovering that economic freedom is the only source of national wealth. In time, they will find that social and political freedom is the only source of national greatness. America will encourage the advancement of democracy and economic openness in both nations, because these are the best foundations for domestic stability and international order. We will strongly resist aggression from other great powers—even as we welcome their peaceful pursuit of prosperity, trade, and cultural advancement.

Finally, the United States will use this moment of opportunity to extend the benefits of freedom across the globe. We will actively work to bring the hope of democracy, development, free markets, and free trade to every corner of the world. The events of September 11, 2001, taught us that weak states, like Afghanistan, can pose as great a danger to our national interests as strong states. Poverty does not make poor people into terrorists and murderers. Yet poverty, weak institutions, and corruption can make weak states vulnerable to terrorist networks and drug cartels within their borders.

The United States will stand beside any nation determined to build a better future by seeking the rewards of liberty for its people. Free trade and free markets have proven their ability to lift whole societies out of poverty—so the United States will work with individual nations, entire regions, and the entire global trading community to build a world that trades in freedom and therefore grows in prosperity. The United States will deliver greater development assistance through the New Millennium Challenge Account to nations that govern justly, invest in their people, and encourage economic freedom. We will also continue to lead the world in efforts to reduce the terrible toll of HIV/AIDS and other infectious diseases.

In building a balance of power that favors freedom, the United States is guided by the conviction that all nations have important responsibilities. Nations that enjoy freedom must actively fight terror. Nations that depend on international stability must help prevent the spread of weapons of mass destruction. Nations that seek international aid must govern themselves wisely, so that aid is well spent. For freedom to thrive, accountability must be expected and required. We are also guided by the conviction that no nation can build a safer, better world alone. Alliances and multilateral institutions can multiply the strength of freedom-loving nations.

The United States is committed to lasting institutions like the United Nations, the World Trade Organization, the Organization of American States, and NATO as well as other long-standing alliances. Coalitions of the willing can augment these permanent institutions. In all cases, international obligations are to be taken seriously. They are not to be undertaken symbolically to rally support for an ideal without furthering its attainment.

Freedom is the non-negotiable demand of human dignity; the birthright of every person—in every civilization. Throughout history, freedom has been threatened by war and terror; it has been challenged by the clashing wills of powerful states and the evil designs of tyrants; and it has been tested by widespread poverty and disease. Today, humanity holds in its hands the opportunity to further freedom's triumph over all these foes. The United States welcomes our responsibility to lead in this great mission.

George W. Bush
THE WHITE HOUSE,
September 17, 2002

EXCERPT FROM 2002 NATIONAL SECURITY STRATEGY OF THE UNITED STATES

v. Prevent Our Enemies from Threatening Us, Our Allies, and Our Friends with Weapons of Mass Destruction

"The gravest danger to freedom lies at the crossroads of radicalism and technology. When the spread of chemical and biological and nuclear weapons, along with ballistic missile technology—when that occurs, even weak states and small groups could attain a catastrophic power to strike great nations. Our enemies have declared this very intention, and have been caught seeking these terrible weapons. They want the capability to blackmail us, or to harm us, or to harm our friends—and we will oppose them with all our power."

President Bush
West Point, New York
June 1, 2002

The nature of the Cold War threat required the United States—with our allies and friends—to emphasize deterrence of the enemy's use of force, producing a grim strategy of mutual assured destruction. With the collapse of the Soviet Union and the end of the Cold War, our security environment has undergone profound transformation. Having moved from confrontation to cooperation as the hallmark of our relationship with Russia, the dividends are evident: an end to the balance of terror that divided us; an historic reduction in the nuclear arsenals on both sides; and cooperation in areas such as counterterrorism and missile defense that until recently were inconceivable. But new deadly challenges have emerged from rogue states and terrorists. None of these contemporary threats rival the sheer destructive power that was arrayed against us by the Soviet Union. However, the nature and motivations of these new adversaries, their determination to obtain destructive powers hitherto available only to the world's strongest states, and the greater likelihood that they will use weapons of mass destruction against us, make today's security environment more complex and dangerous. In the 1990s we witnessed the emergence of a small number of rogue states that, while different in important ways, share a number of attributes.

These states:

- brutalize their own people and squander their national resources for the personal gain of the rulers;
- display no regard for international law, threaten their neighbors, and callously violate international treaties to which they are party;
- are determined to acquire weapons of mass destruction, along with other advanced military technology, to be used as threats or offensively to achieve the aggressive designs of these regimes;
- sponsor terrorism around the globe; and
- reject basic human values and hate the United States and everything for which it stands.

At the time of the Gulf War, we acquired irrefutable proof that Iraq's designs were not

limited to the chemical weapons it had used against Iran and its own people, but also extended to the acquisition of nuclear weapons and biological agents. In the past decade North Korea has become the world's principal purveyor of ballistic missiles, and has tested increasingly capable missiles while developing its own WMD arsenal.

Other rogue regimes seek nuclear, biological, and chemical weapons as well. These states' pursuit of, and global trade in, such weapons has become a looming threat to all nations. We must be prepared to stop rogue states and their terrorist clients before they are able to threaten or use weapons of mass destruction against the United States and our allies and friends. Our response must take full advantage of strengthened alliances, the establishment of new partnerships with former adversaries, innovation in the use of military forces, modern technologies, including the development of an effective missile defense system, and increased emphasis on intelligence collection and analysis.

Our comprehensive strategy to combat WMD includes:

- *Proactive counterproliferation efforts.* We must deter and defend against the threat before it is unleashed. We must ensure that key capabilities—detection, active and passive defenses, and counterforce capabilities—are integrated into our defense transformation and our homeland security systems. Counterproliferation must also be integrated into the doctrine, training, and equipping of our forces and those of our allies to ensure that we can prevail in any conflict with WMD-armed adversaries.
- *Strengthened nonproliferation efforts to prevent rogue states and terrorists from acquiring the materials, technologies, and expertise necessary for weapons of mass destruction.* We will enhance diplomacy, arms control, multilateral export controls, and threat reduction assistance that impede states and terrorists seeking WMD, and when necessary, interdict enabling technologies and materials. We will continue to build coalitions to support these efforts, encouraging their increased political and financial support for nonproliferation and threat reduction programs. The recent G-8 agreement to commit up to $20 billion to a global partnership against proliferation marks a major step forward.
- *Effective consequence management to respond to the effects of WMD use, whether by terrorists or hostile states.* Minimizing the effects of WMD use against our people will help deter those who possess such weapons and dissuade those who seek to acquire them by persuading enemies that they cannot attain their desired ends. The United States must also be prepared to respond to the effects of WMD use against our forces abroad, and to help friends and allies if they are attacked.

It has taken almost a decade for us to comprehend the true nature of this new threat. Given the goals of rogue states and terrorists, the United States can no longer solely rely on a reactive posture as we have in the past. The inability to deter a potential attacker, the immediacy of today's threats, and the magnitude of potential harm that could be caused by our adversaries' choice of weapons, do not permit that option. We cannot let our enemies strike first.

- In the Cold War, especially following the Cuban missile crisis, we faced a generally status quo, risk-averse adversary. Deterrence was an effective defense. But deterrence based only upon the threat of retaliation is less likely to work against leaders of rogue states more willing to take risks, gambling with the lives of their people, and the wealth of their nations.
- In the Cold War, weapons of mass destruction were considered weapons of last resort whose use risked the destruction of those who used them. Today, our enemies see weapons of mass destruction as weapons of choice. For rogue states these weapons are tools of intimidation and military aggression against their neighbors. These weapons may also allow these states to attempt to blackmail the United States and our allies to prevent us from deterring or repelling the aggressive behavior of rogue states. Such states also see these weapons as their best means of overcoming the conventional superiority of the United States.
- Traditional concepts of deterrence will not work against a terrorist enemy whose avowed tactics are wanton destruction and the targeting of innocents; whose so-called soldiers seek martyrdom in death and whose most potent protection is statelessness. The overlap between states that sponsor terror and those that pursue WMD compels us to action.

For centuries, international law recognized that nations need not suffer an attack before they can lawfully take action to defend themselves against forces that present an imminent danger of attack. Legal scholars and international jurists often conditioned the legitimacy of preemption on the existence of an imminent threat—most often a visible mobilization of armies, navies, and air forces preparing to attack.

We must adapt the concept of imminent threat to the capabilities and objectives of today's adversaries. Rogue states and terrorists do not seek to attack us using conventional means. They know such attacks would fail. Instead, they rely on acts of terror and, potentially, the use of weapons of mass destruction—weapons that can be easily concealed, delivered covertly, and used without warning.

The targets of these attacks are our military forces and our civilian population, in direct violation of one of the principal norms of the law of warfare. As was demonstrated by the losses on September 11, 2001, mass civilian casualties is the specific objective of terrorists and these losses would be exponentially more severe if terrorists acquired and used weapons of mass destruction.

The United States has long maintained the option of preemptive actions to counter a sufficient threat to our national security. The greater the threat, the greater is the risk of inaction—and the more compelling the case for taking anticipatory action to defend ourselves, even if uncertainty remains as to the time and place of the enemy's attack. To forestall or prevent such hostile acts by our adversaries, the United States will, if necessary, act preemptively.

The United States will not use force in all cases to preempt emerging threats, nor should nations use preemption as a pretext for aggression. Yet in an age where the enemies of civilization openly and actively seek the world's most destructive technologies, the United States cannot remain idle while dangers gather.

We will always proceed deliberately, weighing the consequences of our actions. To support preemptive options, we will:

- build better, more integrated intelligence capabilities to provide timely, accurate information on threats, wherever they may emerge;
- coordinate closely with allies to form a common assessment of the most dangerous threats; and
- continue to transform our military forces to ensure our ability to conduct rapid and precise operations to achieve decisive results.

The purpose of our actions will always be to eliminate a specific threat to the United States or our allies and friends. The reasons for our actions will be clear, the force measured, and the cause just.

National Strategy to Combat Weapons of Mass Destruction

December 2002

INTRODUCTION

Weapons of mass destruction (WMD)—nuclear, biological, and chemical—in the possession of hostile states and terrorists represent one of the greatest security challenges facing the United States. We must pursue a comprehensive strategy to counter this threat in all of its dimensions. An effective strategy for countering WMD, including their use and further proliferation, is an integral component of the National Security Strategy of the United States of America. As with the war on terrorism, our strategy for homeland security, and our new concept of deterrence, the U.S. approach to combat WMD represents a fundamental change from the past. To succeed, we must take full advantage of today's opportunities, including the application of new technologies, increased emphasis on intelligence collection and analysis, the strengthening of alliance relationships, and the establishment of new partnerships with former adversaries. Weapons of mass destruction could enable adversaries to inflict massive harm on the United States, our military forces at home and abroad, and our friends and allies. Some states, including several that have supported and continue to support terrorism, already possess WMD and are seeking even greater capabilities, as tools of coercion and intimidation. For them, these are not weapons of last resort, but militarily useful weapons of choice intended to overcome our nation's advantages in conventional forces and to deter us from responding to aggression against our friends and allies in regions of vital interest. In addition, terrorist groups are seeking to acquire WMD with the stated purpose of killing large numbers of our people and those of friends and allies—without compunction and without warning.

We will not permit the world's most dangerous regimes and terrorists to threaten us with the world's most destructive weapons. We must accord the highest priority to the protection of the United States, our forces, and our friends and allies from the existing and growing WMD threat.

> "*The gravest danger our Nation faces lies at the crossroads of radicalism and technology. Our enemies have openly declared that they are seeking weapons of mass destruction, and evidence indicates that they are doing so with determination The United States will not allow these efforts to succeed. ...History will judge harshly those who saw this coming danger but failed to act. In the new world we have entered, the only path to peace and security is the path of action.*"
>
> President Bush
> The National Security Strategy of the
> United States of America
> September 17, 2002

PILLARS OF OUR NATIONAL SECURITY

Our National Strategy to Combat Weapons of Mass Destruction has three principal pillars:

Counterproliferation to Combat WMD Use

The possession and increased likelihood of use of WMD by hostile states and terrorists are realities of the contemporary security environment. It is therefore critical that the U.S. military and appropriate civilian agencies be prepared to deter and defend against the full range of possible WMD employment scenarios. We will ensure that all needed capabilities to combat WMD are fully integrated into the emerging defense transformation plan and into our homeland security posture. Counterproliferation will also be fully integrated into the basic doctrine, training, and equipping of all forces, in order to ensure that they can sustain operations to decisively defeat WMD-armed adversaries.

Strengthened Nonproliferation to Combat WMD Proliferation

The United States, our friends and allies, and the broader international community must undertake every effort to prevent states and terrorists from acquiring WMD and missiles. We must enhance traditional measures—diplomacy, arms control, multilateral agreements, threat reduction assistance, and export controls—that seek to dissuade or impede proliferant states and terrorist networks, as well as to slow and make more costly their access to sensitive technologies, material, and expertise. We must ensure compliance with relevant international agreements, including the Nuclear Nonproliferation Treaty (NPT), the Chemical Weapons Convention (CWC), and the Biological Weapons Convention (BWC). The United States will continue to work with other states to improve their capability to prevent unauthorized transfers of WMD and missile technology, expertise, and material. We will identify and pursue new methods of prevention, such as national criminalization of proliferation activities and expanded safety and security measures.

Consequence Management to Respond to WMD Use

Finally, the United States must be prepared to respond to the use of WMD against our citizens, our military forces, and those of friends and allies. We will develop and maintain the capability to reduce to the extent possible the potentially horrific consequences of WMD attacks at home and broad. The three pillars of the U.S. national strategy to combat WMD are seamless elements of a comprehensive approach. Serving to integrate the pillars are four cross-cutting enabling functions that need to be pursued on a priority basis: intelligence collection and analysis on WMD, delivery systems, and related technologies; research and development to improve our ability to respond to evolving threats; bilateral and multilateral cooperation; and targeted strategies against hostile states and terrorists.

COUNTERPROLIFERATION

We know from experience that we cannot always be successful in preventing and containing the proliferation of WMD to hostile states and terrorists. Therefore, U.S. military and appropriate civilian agencies must possess the full range of operational capabilities to counter the threat and use of WMD by states and terrorists against the United States, our military forces, and friends and allies. Interdiction Effective interdiction is a critical part of the U.S. strategy to combat WMD and their delivery means. We must enhance the capabilities of our military, intelligence, technical, and law enforcement communities to prevent the movement of WMD materials, technology, and expertise to hostile states and terrorist organizations.

Deterrence Today's threats are far more diverse and less predictable than those of the past. States hostile to the United States and to our friends and allies have demonstrated their willingness to take high risks to achieve their goals, and are aggressively pursuing WMD and their means of delivery as critical tools in this effort. As a consequence, we require new methods of deterrence. A strong declaratory policy and effective military forces are essential elements of our contemporary deterrent posture, along with the full range of political tools to persuade potential adversaries not to seek or use WMD. The United States will continue to make clear that it reserves the right to respond with overwhelming force—including through resort to all of our options—to the use of WMD against the United States, our forces abroad, and friends and allies. In addition to our conventional and nuclear response and defense capabilities, our overall deterrent posture against WMD threats is reinforced by effective intelligence, surveillance, interdiction, and domestic law enforcement capabilities. Such combined capabilities enhance deterrence both by devaluing an adversary's WMD and missiles, and by posing the prospect of an overwhelming response to any use of such weapons. Defense and Mitigation Because deterrence may not succeed, and because of the potentially devastating consequences of WMD use against our forces and civilian population, U.S. military forces and appropriate civilian agencies must have the capability to defend against WMD-armed adversaries, including in appropriate cases through preemptive measures. This requires capabilities to detect and destroy an adversary's WMD assets before these weapons are used. In addition, robust active and passive defenses and mitigation measures must be in place to enable U.S. military forces and appropriate civilian agencies to accomplish their missions, and to assist friends and allies when WMD are used.

Active defenses disrupt, disable, or destroy WMD en route to their targets. Active defenses include vigorous air defense and effective missile defenses against today's threats. Passive defenses must be tailored to the unique characteristics of the various forms of WMD. The United States must also have the ability rapidly and effectively to mitigate the effects of a WMD attack against our deployed forces.

Our approach to defend against biological threats has long been based on our approach to chemical threats, despite the fundamental differences between these weapons. The United States is developing a new approach to provide us and our friends and allies with an effective defense against biological weapons.

Finally, U.S. military forces and domestic law enforcement agencies as appropriate must stand ready to respond against the source of any WMD attack. The primary objective of a response is to disrupt an imminent attack or an attack in progress, and eliminate the threat of future attacks. As with deterrence and prevention, an effective response requires rapid attribution and robust strike capability. We must accelerate efforts to field new capabilities to defeat WMD related assets. The United States needs to be prepared to conduct post-conflict operations to destroy or dismantle any residual WMD capabilities of the hostile state or terrorist network. An effective U.S. response not only will eliminate the source of a WMD attack but will also have a powerful deterrent effect upon other adversaries that possess or seek WMD or missiles.

NONPROLIFERATION

Active Nonproliferation Diplomacy

The United States will actively employ diplomatic approaches in bilateral and multilateral settings in pursuit of our nonproliferation goals.

We must dissuade supplier states from cooperating with proliferant states and induce proliferant states to end their WMD and missile programs. We will hold countries responsible for complying with their commitments. In addition, we will continue to build coalitions to support our efforts, as well as to seek their increased support for nonproliferation and threat reduction cooperation programs. However, should our wide-ranging nonproliferation efforts fail, we must have available the full range of operational capabilities necessary to defend against the possible employment of WMD.

Multilateral Regimes

Existing nonproliferation and arms control regimes play an important role in our overall strategy. The United States will support those regimes that are currently in force, and work to improve the effectiveness of, and compliance with, those regimes. Consistent with other policy priorities, we will also promote new agreements and arrangements that serve our nonproliferation goals.

Overall, we seek to cultivate an international environment that is more conducive to nonproliferation. Our efforts will include:

Nuclear

- Strengthening of the Nuclear Nonproliferation Treaty and International Atomic Energy Agency (IAEA), including through ratification of an IAEA Additional Protocol by all NPT states parties, assurances that all states put in place full-scope IAEA safeguards agreements, and appropriate increases in funding for the Agency;
- Negotiating a Fissile Material Cut-Off Treaty that advances U.S. security interests; and
- Strengthening the Nuclear Suppliers Group and Zangger Committee.

Chemical and Biological

- Effective functioning of the Organization for the Prohibition of Chemical Weapons;
- Identification and promotion of constructive and realistic measures to strengthen the BWC and thereby to help meet the biological weapons threat; and
- Strengthening of the Australia Group.

Missile

- Strengthening the Missile Technology Control Regime (MTCR), including through support for universal adherence to the International Code of Conduct Against Ballistic Missile Proliferation. Nonproliferation and Threat Reduction Cooperation

The United States pursues a wide range of programs, including the Nunn-Lugar program, designed to address the proliferation threat stemming from the large quantities of Soviet-legacy WMD and missile-related expertise and materials. Maintaining an extensive and efficient set of nonproliferation and threat reduction assistance programs to Russia and other former Soviet states is a high priority. We will also continue to encourage friends and allies to increase their contributions to these programs, particularly through the G-8 Global Partnership Against the Spread of Weapons and Materials of Mass Destruction. In addition, we will work with other states to improve the security of their WMD related materials.

Controls on Nuclear Materials

In addition to programs with former Soviet states to reduce fissile material and improve the security of that which remains, the United States will continue to discourage the worldwide accumulation of separated plutonium and to minimize the use of highly-enriched uranium. As outlined in the National Energy Policy, the United States will work in collaboration with international partners to develop recycle and fuel treatment technologies that are cleaner, more efficient, less waste-intensive, and more proliferation-resistant. U.S. Export Controls

We must ensure that the implementation of U.S. export controls furthers our nonproliferation and other national security goals, while recognizing the realities that American businesses face in the increasingly globalized marketplace.

We will work to update and strengthen export controls using existing authorities. We also seek new legislation to improve the ability of our export control system to give full weight to both nonproliferation objectives and commercial interests. Our overall goal is to focus our resources in truly sensitive exports to hostile states or those that engage in onward proliferation, while removing unnecessary barriers in the global marketplace.

Nonproliferation Sanctions

Sanctions can be a valuable component of our overall strategy against WMD proliferation. At times, however, sanctions have proven inflexible and ineffective. We will develop a comprehensive sanctions policy to better integrate sanctions into our overall strategy and work with Congress to consolidate and modify existing sanctions legislation.

WMD CONSEQUENCE MANAGEMENT

Defending the American homeland is the most basic responsibility of our government. As part of our defense, the United States must be fully prepared to respond to the consequences of WMD use on our soil, whether by hostile states or by terrorists. We must also be prepared to respond to the effects of WMD use against our forces deployed abroad, and to assist friends and allies.

The National Strategy for Homeland Security discusses U.S. Government programs to deal with the consequences of the use of a chemical, biological, radiological, or nuclear weapon in the United States. A number of these programs offer training, planning, and assistance to state and local governments. To maximize their effectiveness, these efforts need to be integrated and comprehensive. Our first responders must have the full range of protective, medical, and remediation tools to identify, assess, and respond rapidly to a WMD event on our territory. The White House Office of Homeland Security will coordinate all federal efforts to prepare for and mitigate the consequences of terrorist attacks within the United States, including those involving WMD. The Office of Homeland Security will also work closely with state and local governments to ensure their planning, training, and equipment requirements are addressed. These issues, including the roles of the Department of Homeland Security, are addressed in detail in the National Strategy for Homeland Security. The National Security Council's Office of Combating Terrorism coordinates and helps improve U.S. efforts to respond to and manage the recovery from terrorist attacks outside the United States. In cooperation with the Office of Combating Terrorism, the Department of State coordinates interagency efforts to work with our friends and allies to develop their own emergency preparedness and consequence management capabilities.

INTEGRATING THE PILLARS

Several critical enabling functions serve to integrate the three pillars—counterproliferation, nonproliferation, and consequence management—of the U.S. National Strategy to Combat WMD.

Improved Intelligence Collection and Analysis

A more accurate and complete understanding of the full range of WMD threats is, and will remain, among the highest U.S. intelligence priorities, to enable us to prevent proliferation, and to deter or defend against those who would use those capabilities against us. Improving our ability to obtain timely and accurate knowledge of adversaries' offensive and defensive capabilities, plans, and intentions is key to developing effective counter- and nonproliferation policies and capabilities. Particular emphasis must be accorded to improving: intelligence regarding WMD-related facilities and activities; interaction among U.S. intelligence, law enforcement, and military agencies; and intelligence cooperation with friends and allies.

Research and Development

The United States has a critical need for cutting-edge technology that can quickly and effectively detect, analyze, facilitate interdiction of, defend against, defeat, and mitigate the consequences of WMD. Numerous U.S. Government departments and agencies are currently engaged in the essential research and development to support our overall strategy against WMD proliferation. The new Counterproliferation Technology Coordination Committee, consisting of senior representatives from all concerned agencies, will act to improve interagency coordination of U.S. Government counterproliferation research and development efforts. The Committee will assist in identifying priorities, gaps, and overlaps in existing programs and in examining options for future investment strategies.

Strengthened International Cooperation

WMD represent a threat not just to the United States, but also to our friends and allies and the broader international community. For this reason, it is vital that we work closely with like-minded countries on all elements of our comprehensive proliferation strategy.

Targeted Strategies Against Proliferants

All elements of the overall U.S. strategy to combat WMD must be brought to bear in targeted strategies against supplier and recipient states of WMD proliferation concern, as well as against terrorist groups which seek to acquire WMD. A few states are dedicated proliferators, whose leaders are determined to develop, maintain, and improve their WMD and delivery capabilities, which directly threaten the United States, U.S. forces overseas, and/or our friends and allies. Because each of these regimes is different, we will pursue country-specific strategies that best enable us and our friends and allies to prevent, deter, and defend against WMD and missile threats from each of them. These strategies must also take into account the growing cooperation among proliferant states—so-called secondary proliferation—which challenges us to think in new ways about specific country strategies.

One of the most difficult challenges we face is to prevent, deter, and defend against the acquisition and use of WMD by terrorist groups. The current and potential future linkages between terrorist groups and state sponsors of terrorism are particularly dangerous and require priority attention. The full range of counterproliferation, nonproliferation, and consequence management measures must be brought to bear against the WMD terrorist threat, just as they are against states of greatest proliferation concern.

End Note

Our National Strategy to Combat WMD requires much of all of us—the Executive Branch, the Congress, state and local governments, the American people, and our friends and allies. The requirements to prevent, deter, defend against, and respond to today's WMD threats are complex and challenging. But they are not daunting. We can and will succeed in the tasks laid out in this strategy; we have no other choice.

The North Atlantic Treaty

Washington D.C. - 4 April 1949

The Parties to this Treaty reaffirm their faith in the purposes and principles of the Charter of the United Nations and their desire to live in peace with all peoples and all govern-

ments. They are determined to safeguard the freedom, common heritage and civilisation of their peoples, founded on the principles of democracy, individual liberty and the rule of law. They seek to promote stability and well-being in the North Atlantic area. They are resolved to unite their efforts for collective defence and for the preservation of peace and security. They therefore agree to this North Atlantic Treaty :

ARTICLE 1

The Parties undertake, as set forth in the Charter of the United Nations, to settle any international dispute in which they may be involved by peaceful means in such a manner that international peace and security and justice are not endangered, and to refrain in their international relations from the threat or use of force in any manner inconsistent with the purposes of the United Nations.

ARTICLE 2

The Parties will contribute toward the further development of peaceful and friendly international relations by strengthening their free institutions, by bringing about a better understanding of the principles upon which these institutions are founded, and by promoting conditions of stability and well-being. They will seek to eliminate conflict in their international economic policies and will encourage economic collaboration between any or all of them.

ARTICLE 3

In order more effectively to achieve the objectives of this Treaty, the Parties, separately and jointly, by means of continuous and effective self-help and mutual aid, will maintain and develop their individual and collective capacity to resist armed attack.

ARTICLE 4

The Parties will consult together whenever, in the opinion of any of them, the territorial integrity, political independence or security of any of the Parties is threatened.

ARTICLE 5

The Parties agree that an armed attack against one or more of them in Europe or North America shall be considered an attack against them all and consequently they agree that, if such an armed attack occurs, each of them, in exercise of the right of individual or collective self-defence recognised by Article 51 of the Charter of the United Nations, will assist the Party or Parties so attacked by taking forthwith, individually and in concert with the other Parties, such action as it deems necessary, including the use of armed force, to restore and maintain the security of the North Atlantic area.

Any such armed attack and all measures taken as a result thereof shall immediately be reported to the Security Council. Such measures shall be terminated when the Security Council has taken the measures necessary to restore and maintain international peace and security.

ARTICLE 6 (1)

For the purpose of Article 5, an armed attack on one or more of the Parties is deemed to include an armed attack:

on the territory of any of the Parties in Europe or North America, on the Algerian Departments of France (2), on the territory of or on the Islands under the jurisdiction of any of the Parties in the North Atlantic area north of the Tropic of Cancer;

on the forces, vessels, or aircraft of any of the Parties, when in or over these territories or any other area in Europe in which occupation forces of any of the Parties were stationed on the date when the Treaty entered into force or the Mediterranean Sea or the North Atlantic area north of the Tropic of Cancer.

ARTICLE 7

This Treaty does not affect, and shall not be interpreted as affecting in any way the rights and obligations under the Charter of the Parties which are members of the United Nations, or the primary responsibility of the Security Council for the maintenance of international peace and security.

ARTICLE 8

Each Party declares that none of the international engagements now in force between it and any other of the Parties or any third State is in conflict with the provisions of this Treaty, and undertakes not to enter into any international engagement in conflict with this Treaty.

ARTICLE 9

The Parties hereby establish a Council, on which each of them shall be represented, to consider matters concerning the implementation of this Treaty. The Council shall be so organised as to be able to meet promptly at any time. The Council shall set up such subsidiary bodies as may be necessary; in particular it shall establish immediately a defence committee which shall recommend measures for the implementation of Articles 3 and 5.

ARTICLE 10

The Parties may, by unanimous agreement, invite any other European State in a position to further the principles of this Treaty and to contribute to the security of the North Atlantic area to accede to this Treaty. Any State so invited may become a Party to the Treaty by depositing its instrument of accession with the Government of the United States of America. The Government of the United States of America will inform each of the Parties of the deposit of each such instrument of accession.

ARTICLE 11

This Treaty shall be ratified and its provisions carried out by the Parties in accordance with their respective constitutional processes. The instruments of ratification shall be deposited as soon as possible with the Government of the United States of America, which will notify all the other signatories of each deposit. The Treaty shall enter into force between the States which have ratified it as soon as the ratifications of the majority of the signatories, including the ratifications of Belgium, Canada, France, Luxembourg, the Netherlands, the United Kingdom and the United States, have been deposited and shall come into effect with respect to other States on the date of the deposit of their ratifications. (3)

ARTICLE 12

After the Treaty has been in force for ten years, or at any time thereafter, the Parties shall, if any of them so requests, consult together for the purpose of reviewing the Treaty, having regard for the factors then affecting peace and security in the North Atlantic area, including the development of universal as well as regional arrangements under the Charter of the United Nations for the maintenance of international peace and security.

ARTICLE 13

After the Treaty has been in force for twenty years, any Party may cease to be a Party one year after its notice of denunciation has been given to the Government of the United States of America, which will inform the Governments of the other Parties of the deposit of each notice of denunciation.

ARTICLE 14

This Treaty, of which the English and French texts are equally authentic, shall be deposited in the archives of the Government of the United States of America. Duly certified copies will be transmitted by that Government to the Governments of other signatories.

Footnotes :

(1) The definition of the territories to which Article 5 applies was revised by Article 2 of the Protocol to the North Atlantic Treaty on the accession of Greece and Turkey signed on 22 October 1951.

(2) On January 16, 1963, the North Atlantic Council noted that insofar as the former Algerian Departments of France were concerned, the relevant clauses of this Treaty had become inapplicable as from July 3, 1962.

(3) The Treaty came into force on 24 August 1949, after the deposition of the ratifications of all signatory states.

Treaty on the Non-Proliferation of Nuclear Weapons

Signed at Washington, London, and Moscow July 1, 1968
Ratification advised by U.S. Senate March 13, 1969
Ratified by U.S. President November 24, 1969
Entered into force March 5, 1970

The States concluding this Treaty, hereinafter referred to as the "Parties to the Treaty",

Considering the devastation that would be visited upon all mankind by a nuclear war and the consequent need to make every effort to avert the danger of such a war and to take measures to safeguard the security of peoples,

Believing that the proliferation of nuclear weapons would seriously enhance the danger of nuclear war,

In conformity with resolutions of the United Nations General Assembly calling for the conclusion of an agreement on the prevention of wider dissemination of nuclear weapons, Undertaking to cooperate in facilitating the application of International Atomic Energy Agency safeguards on peaceful nuclear activities,

Expressing their support for research, development and other efforts to further the application, within the framework of the International Atomic Energy Agency safeguards system, of the principle of safeguarding effectively the flow of source and special fissionable materials by use of instruments and other techniques at certain strategic points,

Affirming the principle that the benefits of peaceful applications of nuclear technology, including any technological by-products which may be derived by nuclear-weapon States from the development of nuclear explosive devices, should be available for peaceful purposes to all Parties of the Treaty, whether nuclear-weapon or non-nuclear weapon States,

Convinced that, in furtherance of this principle, all Parties to the Treaty are entitled to participate in the fullest possible exchange of scientific information for, and to contribute alone or in cooperation with other States to, the further development of the applications of atomic energy for peaceful purposes,

Declaring their intention to achieve at the earliest possible date the cessation of the nuclear arms race and to undertake effective measures in the direction of nuclear disarmament,

Urging the cooperation of all States in the attainment of this objective,

Recalling the determination expressed by the Parties to the 1963 Treaty banning nuclear weapon tests in the atmosphere, in outer space and under water in its Preamble to seek to achieve the discontinuance of all test explosions of nuclear weapons for all time and to continue negotiations to this end,

Desiring to further the easing of international tension and the strengthening of trust between States in order to facilitate the cessation of the manufacture of nuclear weapons, the liquidation of all their existing stockpiles, and the elimination from national arsenals of nuclear weapons and the means of their delivery pursuant to a Treaty on general and complete disarmament under strict and effective international control,

Recalling that, in accordance with the Charter of the United Nations, States must refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any State, or in any other manner inconsistent with the Purposes of the United Nations, and that the establishment and maintenance of international peace and security are to be promoted with the least diversion for armaments of the worlds human and economic resources,

Have agreed as follows:

ARTICLE I

Each nuclear-weapon State Party to the Treaty undertakes not to transfer to any recipient whatsoever nuclear weapons or other nuclear explosive devices or control over such weapons or explosive devices directly, or indirectly; and not in any way to assist, encourage, or induce any non-nuclear weapon State to manufacture or otherwise acquire nuclear weapons or other nuclear explosive devices, or control over such weapons or explosive devices.

ARTICLE II

Each non-nuclear-weapon State Party to the Treaty undertakes not to receive the transfer from any transferor whatsoever of nuclear weapons or other nuclear explosive devices or of control over such weapons or explosive devices directly, or indirectly; not to manufacture or otherwise acquire nuclear weapons or other nuclear explosive devices; and not to seek or receive any assistance in the manufacture of nuclear weapons or other nuclear explosive devices.

ARTICLE III

1. Each non-nuclear-weapon State Party to the Treaty undertakes to accept safeguards, as set forth in an agreement to be negotiated and concluded with the International Atomic Energy Agency in accordance with the Statute of the International Atomic Energy Agency and the Agencys safeguards system, for the exclusive purpose of verification of the fulfillment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices. Procedures for the safeguards required by this article shall be followed with respect to source or special fissionable material whether it is being produced, processed or used in any principal nuclear facility or is outside any such facility. The safeguards required by this article shall be applied to all source or special fissionable material in all peaceful nuclear activities within the territory of such State, under its jurisdiction, or carried out under its control anywhere.
2. Each State Party to the Treaty undertakes not to provide: (a) source or special fissionable material, or (b) equipment or material

especially designed or prepared for the processing, use or production of special fissionable material, to any non-nuclear-weapon State for peaceful purposes, unless the source or special fissionable material shall be subject to the safeguards required by this article.

3. The safeguards required by this article shall be implemented in a manner designed to comply with article IV of this Treaty, and to avoid hampering the economic or technological development of the Parties or international cooperation in the field of peaceful nuclear activities, including the international exchange of nuclear material and equipment for the processing, use or production of nuclear material for peaceful purposes in accordance with the provisions of this article and the principle of safeguarding set forth in the Preamble of the Treaty.
4. Non-nuclear-weapon States Party to the Treaty shall conclude agreements with the International Atomic Energy Agency to meet the requirements of this article either individually or together with other States in accordance with the Statute of the International Atomic Energy Agency. Negotiation of such agreements shall commence within 180 days from the original entry into force of this Treaty. For States depositing their instruments of ratification or accession after the 180-day period, negotiation of such agreements shall commence not later than the date of such deposit. Such agreements shall enter into force not later than eighteen months after the date of initiation of negotiations.

ARTICLE IV

1. Nothing in this Treaty shall be interpreted as affecting the inalienable right of all the Parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes without discrimination and in conformity with articles I and II of this Treaty.
2. All the Parties to the Treaty undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy. Parties to the Treaty in a position to do so shall also cooperate in contributing alone or together with other States or international organizations to the further development of the applications of nuclear energy for peaceful purposes, especially in the territories of non-nuclear-weapon States Party to the Treaty, with due consideration for the needs of the developing areas of the world.

ARTICLE V

Each party to the Treaty undertakes to take appropriate measures to ensure that, in accordance with this Treaty, under appropriate international observation and through appropriate international procedures, potential benefits from any peaceful applications of nuclear explosions will be made available to non-nuclear-weapon States Party to the Treaty on a nondiscriminatory basis and that the charge to such Parties for the explosive devices used will be as low as possible and exclude any charge for research and development. Non-nuclear-weapon States Party to the Treaty shall be able to obtain such benefits, pursuant to a special international agreement or agreements, through an appropriate international body with adequate representation of non-nuclear-weapon States. Negotiations on this subject shall commence as soon as possible after the Treaty enters into force. Non-nuclear-weapon States Party to the Treaty so desiring may also obtain such benefits pursuant to bilateral agreements.

ARTICLE VI

Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a Treaty on general and complete disarmament under strict and effective international control.

ARTICLE VII

Nothing in this Treaty affects the right of any group of States to conclude regional treaties in order to assure the total absence of nuclear weapons in their respective territories.

ARTICLE VIII

1. Any Party to the Treaty may propose amendments to this Treaty. The text of any

proposed amendment shall be submitted to the Depositary Governments which shall circulate it to all Parties to the Treaty. Thereupon, if requested to do so by one-third or more of the Parties to the Treaty, the Depositary Governments shall convene a conference, to which they shall invite all the Parties to the Treaty, to consider such an amendment.

2. Any amendment to this Treaty must be approved by a majority of the votes of all the Parties to the Treaty, including the votes of all nuclear-weapon States Party to the Treaty and all other Parties which, on the date the amendment is circulated, are members of the Board of Governors of the International Atomic Energy Agency. The amendment shall enter into force for each Party that deposits its instrument of ratification of the amendment upon the deposit of such instruments of ratification by a majority of all the Parties, including the instruments of ratification of all nuclear-weapon States Party to the Treaty and all other Parties which, on the date the amendment is circulated, are members of the Board of Governors of the International Atomic Energy Agency. Thereafter, it shall enter into force for any other Party upon the deposit of its instrument of ratification of the amendment.
3. Five years after the entry into force of this Treaty, a conference of Parties to the Treaty shall be held in Geneva, Switzerland, in order to review the operation of this Treaty with a view to assuring that the purposes of the Preamble and the provisions of the Treaty are being realized. At intervals of five years thereafter, a majority of the Parties to the Treaty may obtain, by submitting a proposal to this effect to the Depositary Governments, the convening of further conferences with the same objective of reviewing the operation of the Treaty.

ARTICLE IX

1. This Treaty shall be open to all States for signature. Any State which does not sign the Treaty before its entry into force in accordance with paragraph 3 of this article may accede to it at any time.
2. This Treaty shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of the United States of America, the United Kingdom of Great Britain and Northern Ireland and the Union of Soviet Socialist Republics, which are hereby designated the Depositary Governments.
3. This Treaty shall enter into force after its ratification by the States, the Governments of which are designated Depositaries of the Treaty, and forty other States signatory to this Treaty and the deposit of their instruments of ratification. For the purposes of this Treaty, a nuclear-weapon State is one which has manufactured and exploded a nuclear weapon or other nuclear explosive device prior to January 1, 1967.
4. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Treaty, it shall enter into force on the date of the deposit of their instruments of ratification or accession.
5. The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification or of accession, the date of the entry into force of this Treaty, and the date of receipt of any requests for convening a conference or other notices.
6. This Treaty shall be registered by the Depositary Governments pursuant to article 102 of the Charter of the United Nations.

ARTICLE X

1. Each Party shall in exercising its national sovereignty have the right to withdraw from the Treaty if it decides that extraordinary events, related to the subject matter of this Treaty, have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other Parties to the Treaty and to the United Nations Security Council three months in advance. Such notice shall include a statement of the extraordinary events it regards as having jeopardized its supreme interests.
2. Twenty-five years after the entry into force of the Treaty, a conference shall be convened to decide whether the Treaty shall continue in force indefinitely, or shall be extended for an additional fixed period or periods. This

decision shall be taken by a majority of the Parties to the Treaty.

ARTICLE XI

This Treaty, the English, Russian, French, Spanish and Chinese texts of which are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of this Treaty shall be transmitted by the Depositary Governments to the Governments of the signatory and acceding States.

IN WITNESS WHEREOF the undersigned, duly authorized, have signed this Treaty.

DONE in triplicate, at the cities of Washington, London and Moscow, this first day of July one thousand nine hundred sixty-eight.

Agreement Between the United States of American and the Union of Soviet Socialist Republics on the Establishment of Nuclear Risk Reduction Centers

Signed at Washington September 15, 1987
Entered into force September 15, 1987

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Affirming their desire to reduce and ultimately eliminate the risk of outbreak of nuclear war, in particular, as a result of misinterpretation, miscalculation, or accident,

Believing that a nuclear war cannot be won and must never be fought,

Believing that agreement on measures for reducing the risk of outbreak of nuclear war serves the interests of strengthening international peace and security,

Reaffirming their obligations under the Agreement on Measures to Reduce the Risk of Outbreak of Nuclear War between the United States of America and the Union of Soviet Socialist Republics of September 30, 1971, and the Agreement between the Government of the United States of America and the Government of the Union of Soviet Socialist Republics on the Prevention of Incidents on and over the High Seas of May 25, 1972,

Have agreed as follows:

ARTICLE 1

Each Party shall establish, in its capital, a national Nuclear Risk Reduction Center that shall operate on behalf of and under the control of its respective Government.

ARTICLE 2

The Parties shall use the Nuclear Risk Reduction Centers to transmit notifications identified in Protocol I which constitutes an integral part of this Agreement.

In the future, the list of notifications transmitted through the Centers may be altered by agreement between the Parties, as relevant new agreements are reached.

ARTICLE 3

The Parties shall establish a special facsimile communications link between their national Nuclear Risk Reduction Centers in accordance with Protocol II which constitutes an integral part of this Agreement.

ARTICLE 4

The Parties shall staff their national Nuclear Risk Reduction Centers as they deem appropriate, so as to ensure their normal functioning.

ARTICLE 5

The Parties shall hold regular meetings between representatives of the Nuclear Risk Reduction Centers at least once each year to consider matters related to the functioning of such Centers.

ARTICLE 6

This Agreement shall not affect the obligations of either Party under other agreements.

ARTICLE 7

This Agreement shall enter into force on the date of its signature.

The duration of this Agreement shall not be limited.

This Agreement may be terminated by either Party upon 12 months written notice to the other Party.

DONE at Washington on September 15, 1987, in two copies, each in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES OF AMERICA:

George P. Shultz

FOR THE UNION OF SOVIET SOCIALIST REPUBLICS:

Eduard A. Shevardnadze

Agreement on Measures to Reduce the Risk of Outbreak of Nuclear War Between the United States of America and the Union of Soviet Socialist Republics

Signed at Washington September 30, 1971
Entered into force September 30, 19715

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties:

Taking into account the devastating consequences that nuclear war would have for all mankind, and recognizing the need to exert every effort to avert the risk of outbreak of such a war, including measures to guard against accidental or unauthorized use of nuclear weapons,

Believing that agreement on measures for reducing the risk of outbreak of nuclear war serves the interests of strengthening international peace and security, and is in no way contrary to the interests of any other country,

Bearing in mind that continued efforts are also needed in the future to seek ways of reducing the risk of outbreak of nuclear war,

Have agreed as follows:

ARTICLE 1

Each Party undertakes to maintain and to improve, as it deems necessary, its existing organizational and technical arrangements to guard against the accidental or unauthorized use of nuclear weapons under its control.

ARTICLE 2

The Parties undertake to notify each other immediately in the event of an accidental, unauthorized or any other unexplained incident involving a possible detonation of a nuclear weapon which could create a risk of outbreak of nuclear war. In the event of such an incident, the Party whose nuclear weapon is involved will immediately make every effort to take necessary measures to render harmless or destroy such weapon without its causing damage.

ARTICLE 3

The Parties undertake to notify each other immediately in the event of detection by missile warning systems of unidentified objects, or in the event of signs of interference with these systems or with related communications facilities, if such occurrences could create a risk of outbreak of nuclear war between the two countries.

ARTICLE 4

Each Party undertakes to notify the other Party in advance of any planned missile launches if such launches will extend beyond its national territory in the direction of the other Party.

ARTICLE 5

Each Party, in other situations involving unexplained nuclear incidents, undertakes to act in sucha manner as to reduce the possibility of its actions being misinterpreted by the other Party. In any such situation, each Party may inform the other Party or request information when in its view, this is warranted by the interests of averting the risk of outbreak of nuclear war.

ARTICLE 6

For transmission of urgent information, notifications and requests for information in situations requiring prompt clarification, the Parties shall make primary use of the Direct Communications Link between the Governments of the United States of America and the Union of Soviet Socialist Republics.

For transmission of other information, notification and requests for information, the Parties, at their own discretion, may use any communications facilities, including diplomatic channels, depending on the degree of urgency.

ARTICLE 7

The Parties undertake to hold consultations, as mutually agreed, to consider questions relating to implementation of the provisions of this Agreement, as well as to discuss possible amendments thereto aimed at further implementation of the purposes of this Agreement.

ARTICLE 8

This Agreement shall be of unlimited duration.

ARTICLE 9

This Agreement shall enter into force upon signature.

DONE at Washington on September 30, 1971, in two copies, each in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES OF AMERICA:

WILLIAM P. ROGERS

FOR THE UNION OF SOVIET SOCIALIST REPUBLICS:

A. GROMYKO

Open Skies Treaty

The States concluding this Treaty, hereinafter referred to collectively as the States Parties or individually as a State Party,

Recalling the commitments they have made in the Conference on Security and Co-operation in Europe to promoting greater openness and transparency in their military activities and to enhancing security by means of confidence- and security-building measures,

Welcoming the historic events in Europe which have transformed the security situation from Vancouver to Vladivostok,

Wishing to contribute to the further development and strengthening of peace, stability and co-operative security in that area by the creation of an Open Skies regime for aerial observation,

Recognizing the potential contribution which an aerial observation regime of this type could make to security and stability in other regions as well,

Noting the possibility of employing such a regime to improve openness and transparency, to facilitate the monitoring of compliance with existing or future arms control agreements and to strengthen the capacity for conflict prevention and crisis management in the framework of the Conference on Security and Co-operation in Europe and in other relevant international institutions,

Envisaging the possible extension of the Open Skies regime into additional fields, such as the protection of the environment,

Seeking to establish agreed procedures to provide for aerial observation of all the territories of States Parties, with the intent of observing a single State Party or groups of States Parties, on the basis of equity and effectiveness while maintaining flight safety,

Noting that the operation of such an Open Skies regime will be without prejudice to States not participating in it,

Have agreed as follows:

ARTICLE I: GENERAL PROVISIONS

1. This Treaty establishes the regime, to be known as the Open Skies regime, for the conduct of observation flights by States Parties over the territories of other States Parties, and sets forth the rights and obligations of the States Parties relating thereto.
2. Each of the Annexes and their related Appendices constitutes an integral part of this Treaty.

ARTICLE II: DEFINITIONS

For the purposes of this Treaty:

1. The term “observed Party” means the State Party or group of States Parties over whose territory an observation flight is conducted or is intended to be conducted, from the time it has received notification thereof from an observing Party until completion of the procedures relating to that flight, or personnel acting on behalf of that State Party or group of States Parties.
2. The term “observing Party” means the State Party or group of States Parties that intends to conduct or conducts an observation flight over the territory of another State Party or group of States Parties, from the time that it has provided notification of its intention to conduct an observation flight until completion of the procedures relating to that flight, or personnel acting on behalf of that State Party or group of States Parties.
3. The term “group of States Parties” means two or more States Parties that have agreed to form a group for the purposes of this Treaty.

4. The term “observation aircraft” means an unarmed, fixed wing aircraft designated to make observation flights, registered by the relevant authorities of a State Party and equipped with agreed sensors. The term “unarmed” means that the observation aircraft used for the purposes of this Treaty is not equipped to carry and employ weapons.
5. The term “observation flight” means the flight of the observation aircraft conducted by an observing Party over the territory of an observed Party, as provided in the flight plan, from the point of entry or Open Skies airfield to the point of exit or Open Skies airfield.
6. The term “transit flight” means a flight of an observation aircraft or transport aircraft conducted by or on behalf of an observing Party over the territory of a third State Party *en route* to or from the territory of the observed Party.
7. The term “transport aircraft” means an aircraft other than an observation aircraft that, on behalf of the observing Party, conducts flights to or from the territory of the observed Party exclusively for the purposes of this Treaty.
8. The term “territory” means the land, including islands, and internal and territorial waters, over which a State Party exercises sovereignty.
9. The term “passive quota” means the number of observation flights that each State Party is obliged to accept as an observed Party.
10. The term “active quota” means the number of observation flights that each State Party has the right to conduct as an observing Party.
11. The term “maximum flight distance” means the maximum distance over the territory of the observed Party from the point at which the observation flight may commence to the point at which that flight may terminate, as specified in Annex A to this Treaty.
12. The term “sensor” means equipment of a category specified in Article IV, paragraph 1 that is installed on an observation aircraft for use during the conduct of observation flights.
13. The term “ground resolution” means the minimum distance on the ground between two closely located objects distinguishable as separate objects.
14. The term “infra-red line-scanning device” means a sensor capable of receiving and visualizing thermal electro-magnetic radiation emitted in the invisible infra-red part of the optical spectrum by objects due to their temperature and in the absence of artificial illumination.
15. The term “observation period” means a specified period of time during an observation flight when a particular sensor installed on the observation aircraft is operating.
16. The term “flight crew” means individuals from any State Party who may include, if the State Party so decides, interpreters and who perform duties associated with the operation or servicing of an observation aircraft or transport aircraft.
17. The term “pilot-in-command” means the pilot on board the observation aircraft who is responsible for the operation of the observation aircraft, the execution of the flight plan, and the safety of the observation aircraft.
18. The term “flight monitor” means an individual who, on behalf of the observed Party, is on board an observation aircraft provided by the observing Party during the observation flight and who performs duties in accordance with Annex G to this Treaty.
19. The term “flight representative” means an individual who, on behalf of the observing Party, is on board an observation aircraft provided by the observed Party during an observation flight and who performs duties in accordance with Annex G to this Treaty.
20. The term “representative” means an individual who has been designated by the observing Party and who performs activities on behalf of the observing Party in accordance with Annex G during an observation flight on an observation aircraft designated by a State Party other than the observing Party or the observed Party.
21. The term “sensor operator” means an individual from any State Party who performs duties associated with the functioning, operation and maintenance of the sensors of an observation aircraft.
22. The term “inspector” means an individual from any State Party who conducts an inspection of sensors or observation aircraft of another State Party.
23. The term “escort” means an individual from any State Party who accompanies the inspectors of another State Party.
24. The term “mission plan” means a document, which is in a format established by the Open Skies Consultative Commission, presented by the observing Party that contains the route, profile, order of execution and support

required to conduct the observation flight, which is to be agreed upon with the observed Party and which will form the basis for the elaboration of the flight plan.

25. The term "flight plan" means a document elaborated on the basis of the agreed mission plan in the format and with the content specified by the International Civil Aviation Organization, hereinafter referred to as the ICAO, which is presented to the air traffic control authorities and on the basis of which the observation flight will be conducted.
26. The term "mission report" means a document describing an observation flight completed after its termination by the observing Party and signed by both the observing and observed Parties, which is in a format established by the Open Skies Consultative Commission.
27. The term "Open Skies airfield" means an airfield designated by the observed Party as a point where an observation flight may commence or terminate.
28. The term "point of entry" means a point designated by the observed Party for the arrival of personnel of the observing Party on the territory of the observed Party.
29. The term "point of exit" means a point designated by the observed Party for the departure of personnel of the observing Party from the territory of the observed Party.
30. The term "refuelling airfield" means an airfield designated by the observed Party used for fuelling and servicing of observation aircraft and transport aircraft.
31. The term "alternate airfield" means an airfield specified in the flight plan to which an observation aircraft or transport aircraft may proceed when it becomes inadvisable to land at the airfield of intended landing.
32. The term "hazardous airspace" means the prohibited areas, restricted areas and danger areas, defined on the basis of Annex 2 to the Convention on International Civil Aviation, that are established in accordance with Annex 15 to the Convention on International Civil Aviation in the interests of flight safety, public safety and environmental protection and about which information is provided in accordance with ICAO provisions.
33. The term "prohibited area" means an airspace of defined dimensions, above the territory of a State Party, within which the flight of aircraft is prohibited.
34. The term "restricted area" means an airspace of defined dimensions, above the territory of a State Party, within which the flight of aircraft is restricted in accordance with specified conditions.
35. The term "danger area" means an airspace of defined dimensions within which activities dangerous to the flight of aircraft may exist at specified times.

ARTICLE III: QUOTAS

SECTION I. GENERAL PROVISIONS

1. Each State Party shall have the right to conduct observation flights in accordance with the provisions of this Treaty.
2. Each State Party shall be obliged to accept observation flights over its territory in accordance with the provisions of this Treaty.
3. Each State Party shall have the right to conduct a number of observation flights over the territory of any other State Party equal to the number of observation flights which that other State Party has the right to conduct over it.
4. The total number of observation flights that each State Party is obliged to accept over its territory is the total passive quota for that State Party. The allocation of the total passive quota to the States Parties is set forth in Annex A, Section I to this Treaty.
5. The number of observation flights that a State Party shall have the right to conduct each year over the territory of each of the other States Parties is the individual active quota of that State Party with respect to that other State Party. The sum of the individual active quotas is the total active quota of that State Party. The total active quota of a State Party shall not exceed its total passive quota.
6. The first distribution of active quotas is set forth in Annex A, Section II to this Treaty.
7. After entry into force of this Treaty, the distribution of active quotas shall be subject to an annual review for the following calendar year within the framework of the Open Skies Consultative Commission. In the event that it is not possible during the annual review to arrive within three weeks at agreement on the distribution of active quotas with respect to a particular State Party, the previous year?s

distribution of active quotas with respect to that State Party shall remain unchanged.

8. Except as provided for by the provisions of Article VIII, each observation flight conducted by a State Party shall be counted against the individual and total active quotas of that State Party.
9. Notwithstanding the provisions of paragraphs 3 and 5 of this Section, a State Party to which an active quota has been distributed may, by agreement with the State Party to be overflown, transfer a part or all of its total active quota to other States Parties and shall promptly notify all other States Parties and the Open Skies Consultative Commission thereof. Paragraph 10 of this Section shall apply.
10. No State Party shall conduct more observation flights over the territory of another State Party than a number equal to 50 per cent, rounded up to the nearest whole number, of its own total active quota, or of the total passive quota of that other State Party, whichever is less.
11. The maximum flight distances of observation flights over the territories of the States Parties are set forth in Annex A, Section III to this Treaty.

SECTION II. PROVISIONS FOR A GROUP OF STATES PARTIES

1.

(A) Without prejudice to their rights and obligations under this Treaty, two or more States Parties which hold quotas may form a group of States Parties at signature of this Treaty and thereafter. For a group of States Parties formed after signature of this Treaty, the provisions of this Section shall apply no earlier than six months after giving notice to all other States Parties, and subject to the provisions of paragraph 6 of this Section.
(B) A group of States Parties shall co-operate with regard to active and passive quotas in accordance with the provisions of either paragraph 2 or 3 of this Section.

2.

(A) The members of a group of States Parties shall have the right to redistribute amongst themselves their active quotas for the current year, while retaining their individual passive quotas. Notification of the redistribution shall be made immediately to all third States Parties concerned.
(B) An observation flight shall count as many observation flights against the individual and total active quotas of the observing Party as observed Parties belonging to the group are overflown. It shall count one observation flight against the total passive quota of each observed Party.
(C) Each State Party in respect of which one or more members of a group of States Parties hold active quotas shall have the right to conduct over the territory of any member of the group 50 per cent more observation flights, rounded up to the nearest whole number, than its individual active quota in respect of that member of the group or to conduct two such overflights if it holds no active quota in respect of that member of the group.
(D) In the event that it exercises this right the State Party concerned shall reduce its active quotas in respect of other members of the group in such a way that the total sum of observation flights it conducts over their territories shall not exceed the sum of the individual active quotas that the State Party holds in respect of all the members of the group in the current year.
(E) The maximum flight distances of observation flights over the territories of each member of the group shall apply. In case of an observation flight conducted over several members, after completion of the maximum flight distance for one member all sensors shall be switched off until the observation aircraft reaches the point over the territory of the next member of the group of States Parties where the observation flight is planned to begin. For such follow-on observation flight the maximum flight distance related to the Open Skies airfield nearest to this point shall apply.

3.

(A) A group of States Parties shall, at its request, be entitled to a common total passive quota which shall be allocated to it and common individual and total active quotas shall be distributed in respect of it.
(B) In this case, the total passive quota is the total number of observation flights that the group of States Parties is obliged to accept each year. The total active quota is the sum of the number of observation flights that the

group of States Parties has the right to conduct each year. Its total active quota shall not exceed the total passive quota.
(C) An observation flight resulting from the total active quota of the group of States Parties shall be carried out on behalf of the group.
(D) Observation flights that a group of States Parties is obliged to accept may be conducted over the territory of one or more of its members.
(E) The maximum flight distances of each group of States Parties shall be specified pursuant to Annex A, Section III and Open Skies airfields shall be designated pursuant to Annex E to this Treaty.

4. In accordance with the general principles set out in Article X, paragraph 3, any third State Party that considers its rights under the provisions of Section I, paragraph 3 of this Article to be unduly restricted by the operation of a group of States Parties may raise this problem before the Open Skies Consultative Commission.
5. The group of States Parties shall ensure that procedures are established allowing for the conduct of observation flights over the territories of its members during one single mission, including refuelling if necessary. In the case of a group of States Parties established pursuant to paragraph 3 of this Section, such observation flights shall not exceed the maximum flight distance applicable to the Open Skies airfields at which the observation flights commence.
6. No earlier than six months after notification of the decision has been provided to all other States Parties:
(A) a group of States Parties established pursuant to the provisions of paragraph 2 of this Section may be transformed into a group of States Parties pursuant to the provisions of paragraph 3 of this Section;
(B) a group of States Parties established pursuant to the provisions of paragraph 3 of this Section may be transformed into a group of States Parties pursuant to the provisions of paragraph 2 of this Section;
(C) a State Party may withdraw from a group of States Parties; or
(D) a group of States Parties may admit further States Parties which hold quotas.
7. Following entry into force of this Treaty, changes in the allocation or distribution of quotas resulting from the establishment of or an admission to or a withdrawal from a group of States Parties according to paragraph 3 of this Section shall become effective on 1 January following the first annual review within the Open Skies Consultative Commission occurring after the six-month notification period. When necessary, new Open Skies airfields shall be designated and maximum flight distances established accordingly.

ARTICLE IV: SENSORS

1. Except as otherwise provided for in paragraph 3 of this Article, observation aircraft shall be equipped with sensors only from amongst the following categories:
(A) optical panoramic and framing cameras;
(B) video cameras with real-time display;
(C) infra-red line-scanning devices; and
(D) sideways-looking synthetic aperture radar.
2. A State Party may use, for the purposes of conducting observation flights, any of the sensors specified in paragraph 1 above, provided that such sensors are commercially available to all States Parties, subject to the following performance limits:
(A) in the case of optical panoramic and framing cameras, a ground resolution of no better than 30 centimetres at the minimum height above ground level determined in accordance with the provisions of Annex D, Appendix 1, obtained from no more than one panoramic camera, one vertically-mounted framing camera and two obliquely-mounted framing cameras, one on each side of the aircraft, providing coverage, which need not be continuous, of the ground up to 50 kilometres of each side of the flight path of the aircraft;
(B) in the case of video cameras, a ground resolution of no better than 30 centimetres determined in accordance with the provisions of Annex D, Appendix 1;
(C) in the case of infra-red line-scanning devices, a ground resolution of no better than 50 centimetres at the minimum height above ground level determined in accordance with the provisions of Annex D, Appendix 1, obtained from a single device; and

(D) in the case of sideways-looking synthetic aperture radar, a ground resolution of no better than three metres calculated by the impulse response method, which, using the object separation method, corresponds to the ability to distinguish on a radar image two corner reflectors, the distance between the centres of which is no less than five metres, over a swath width of no more than 25 kilometres, obtained from a single radar unit capable of looking from either side of the aircraft, but not both simultaneously.

3. The introduction of additional categories and improvements to the capabilities of existing categories of sensors provided for in this Article shall be addressed by the Open Skies Consultative Commission pursuant to Article X of this Treaty.
4. All sensors shall be provided with aperture covers or other devices which inhibit the operation of sensors so as to prevent collection of data during transit flights or flights to points of entry or from points of exit over the territory of the observed Party. Such covers or such other devices shall be removable or operable only from outside the observation aircraft.
5. Equipment that is capable of annotating data collected by sensors in accordance with Annex B, Section II shall be allowed on observation aircraft. The State Party providing the observation aircraft for an observation flight shall annotate the data collected by sensors with the information provided for in Annex B, Section II to this Treaty.
6. Equipment that is capable of displaying data collected by sensors in real-time shall be allowed on observation aircraft for the purposes of monitoring the functioning and operation of the sensors during the conduct of an observation flight.
7. Except as required for the operation of the agreed sensors, or as required for the operation of the observation aircraft, or as provided for in paragraphs 5 and 6 of this Article, the collection, processing, retransmission or recording of electronic signals from electro-magnetic waves are prohibited on board the observation aircraft and equipment for such operations shall not be on that observation aircraft.
8. In the event that the observation aircraft is provided by the observing Party, the observing Party shall have the right to use an observation aircraft equipped with sensors in each sensor category that do not exceed the capability specified in paragraph 2 of this Article.
9. In the event that the observation aircraft used for an observation flight is provided by the observed Party, the observed Party shall be obliged to provide an observation aircraft equipped with sensors from each sensor category specified in paragraph 1 of this Article, at the maximum capability and in the numbers specified in paragraph 2 of this Article, subject to the provisions of Article XVIII, Section II, unless otherwise agreed by the observing and observed Parties. The package and configuration of such sensors shall be installed in such a way so as to provide coverage of the ground provided for in paragraph 2 of this Article. In the event that the observation aircraft is provided by the observed Party, the latter shall provide a sideways-looking synthetic aperture radar with a ground resolution of no worse than six metres, determined by the object separation method.
10. When designating an aircraft as an observation aircraft pursuant to Article V of this Treaty, each State Party shall inform all other States Parties of the technical information on each sensor installed on such aircraft as provided for in Annex B to this Treaty.
11. Each State Party shall have the right to take part in the certification of sensors installed on observation aircraft in accordance with the provisions of Annex D. No observation aircraft of a given type shall be used for observation flights until such type of observation aircraft and its sensors has been certified in accordance with the provisions of Annex D to this Treaty.
12. A State Party designating an aircraft as an observation aircraft shall, upon 90-day prior notice to all other States Parties and subject to the provisions of Annex D to this Treaty, have the right to remove, replace or add sensors, or amend the technical information it has provided in accordance with the provisions of paragraph 10 of this Article and Annex B to this Treaty. Replacement and additional sensors shall be subject to certification in accordance with the provisions of Annex D to this Treaty prior to their use during an observation flight.

13. In the event that a State Party or group of States Parties, based on experience with using a particular observation aircraft, considers that any sensor or its associated equipment installed on an aircraft does not correspond to those certified in accordance with the provisions of Annex D, the interested States Parties shall notify all other States Parties of their concern. The State Party that designated the aircraft shall:
    (A) take the steps necessary to ensure that the sensor and its associated equipment installed on the observation aircraft correspond to those certified in accordance with the provisions of Annex D, including, as necessary, repair, adjustment or replacement of the particular sensor or its associated equipment; and
    (B) at the request of an interested State Party, by means of a demonstration flight set up in connection with the next time that the aforementioned observation aircraft is used, in accordance with the provisions of Annex F, demonstrate that the sensor and its associated equipment installed on the observation aircraft correspond to those certified in accordance with the provisions of Annex D.
    Other States Parties that express concern regarding a sensor and its associated equipment installed on an observation aircraft shall have the right to send personnel to participate in such a demonstration flight.
14. In the event that, after the steps referred to in paragraph 13 of this Article have been taken, the States Parties remain concerned as to whether a sensor or its associated equipment installed on an observation aircraft correspond to those certified in accordance with the provisions of Annex D, the issue may be referred to the Open Skies Consultative Commission.

ARTICLE V: AIRCRAFT DESIGNATION

1. Each State Party shall have the right to designate as observation aircraft one or more types or models of aircraft registered by the relevant authorities of a State Party.
2. Each State Party shall have the right to designate types or models of aircraft as observation aircraft or add new types or models of aircraft to those designated earlier by it, provided that it notifies all other States Parties 30 days in advance thereof. The notification of the designation of aircraft of a type or model shall contain the information specified in Annex C to this Treaty.
3. Each State Party shall have the right to delete types or models of aircraft designated earlier by it, provided that it notifies all other States Parties 90 days in advance thereof.
4. Only one exemplar of a particular type and model of aircraft with an identical set of associated sensors shall be required to be offered for certification in accordance with the provisions of Annex D to this Treaty.
5. Each observation aircraft shall be capable of carrying the flight crew and the personnel specified in Article VI, Section III.

ARTICLE VI: CHOICE OF OBSERVATION AIRCRAFT, GENERAL PROVISIONS FOR THE CONDUCT OF OBSERVATION FLIGHTS, AND REQUIREMENTS FOR MISSION PLANNING

SECTION I. CHOICE OF OBSERVATION AIRCRAFT AND GENERAL PROVISIONS FOR THE CONDUCT OF OBSERVATION FLIGHTS

1. Observation flights shall be conducted using observation aircraft that have been designated by a State Party pursuant to Article V. Unless the observed Party exercises its right to provide an observation aircraft that it has itself designated, the observing Party shall have the right to provide the observation aircraft. In the event that the observing Party provides the observation aircraft, it shall have the right to provide an aircraft that it has itself designated or an aircraft designated by another State Party. In the event that the observed Party provides the observation aircraft, the observing Party shall have the right to be provided with an aircraft capable of achieving a minimum unrefuelled range, including the necessary fuel reserves, equivalent to one-half of the flight distance, as notified in accordance with paragraph 5, subparagraph (G) of this Section.
2. Each State Party shall have the right, pursuant to paragraph 1 of this Section, to use an observation aircraft designated by another State Party for observation flights. Arrangements for the use of such aircraft shall

be worked out by the States Parties involved to allow for active participation in the Open Skies regime.

3. States Parties having the right to conduct observation flights may co-ordinate their plans for conducting observation flights in accordance with Annex H to this Treaty. No State Party shall be obliged to accept more than one observation flight at any one time during the 96-hour period specified in paragraph 9 of this Section, unless that State Party has requested a demonstration flight pursuant to Annex F to this Treaty. In that case, the observed Party shall be obliged to accept an overlap for the observation flights of up to 24 hours. After having been notified of the results of the co-ordination of plans to conduct observation flights, each State Party over whose territory observation flights are to be conducted shall inform other States Parties, in accordance with the provisions of Annex H, whether it will exercise, with regard to each specific observation flight, its right to provide its own observation aircraft.
4. No later than 90 days after signature of this Treaty, each State Party shall provide notification to all other States Parties:
(A) of the standing diplomatic clearance number for Open Skies observation flights, flights of transport aircraft and transit flights; and
(B) of which language or languages of the Open Skies Consultative Commission specified in Annex L, Section I, paragraph 7 to this Treaty shall be used by personnel for all activities associated with the conduct of observation flights over its territory, and for completing the mission plan and mission report, unless the language to be used is the one recommended in Annex 10 to the Convention on International Civil Aviation, Volume II, paragraph 5.2.1.1.2.
5. The observing Party shall notify the observed Party of its intention to conduct an observation flight, no less than 72 hours prior to the estimated time of arrival of the observing Party at the point of entry of the observed Party. States Parties providing such notifications shall make every effort to avoid using the minimum pre-notification period over weekends. Such notification shall include:
(A) the desired point of entry and, if applicable, Open Skies airfield where the observation flight shall commence;
(B) the date and estimated time of arrival of the observing Party at the point of entry and the date and estimated time of departure for the flight from the point of entry to the Open Skies airfield, if applicable, indicating specific accommodation needs;
(C) the location, specified in Annex E, Appendix 1, where the conduct of the pre-flight inspection is desired and the date and start time of such pre-flight inspection in accordance with the provisions of Annex F;
(D) the mode of transport and, if applicable, type and model of the transport aircraft used to travel to the point of entry in the event that the observation aircraft used for the observation flight is provided by the observed Party;
(E) the diplomatic clearance number for the observation flight or for the flight of the transport aircraft used to bring the personnel in and out of the territory of the observed Party to conduct an observation flight;
(F) the identification of the observation aircraft, as specified in Annex C;
(G) the approximate observation flight distance; and
(H) the names of the personnel, their gender, date and place of birth, passport number and issuing State Party, and their function.
6. The observed Party that is notified in accordance with paragraph 5 of this Section shall acknowledge receipt of the notification within 24 hours. In the event that the observed Party exercises its right to provide the observation aircraft, the acknowledgement shall include the information about the observation aircraft specified in paragraph 5, subparagraph (F) of this Section. The observing Party shall be permitted to arrive at the point of entry at the estimated time of arrival as notified in accordance with paragraph 5 of this Section. The estimated time of departure for the flight from the point of entry to the Open Skies airfield where the observation flight shall commence and the location, the date and the start time of the pre-flight inspection shall be subject to confirmation by the observed Party.
7. Personnel of the observing Party may include personnel designated pursuant to Article XIII by other States Parties.
8. The observing Party, when notifying the observed Party in accordance with paragraph 5 of this Section, shall

simultaneously notify all other States Parties of its intention to conduct the observation flight.

9. The period from the estimated time of arrival at the point of entry until completion of the observation flight shall not exceed 96 hours, unless otherwise agreed. In the event that the observed Party requests a demonstration flight pursuant to Annex F to the Treaty, it shall extend the 96-hour period pursuant to Annex F, Section III, paragraph 4, if additional time is required by the observing Party for the unrestricted execution of the mission plan.
10. Upon arrival of the observation aircraft at the point of entry, the observed Party shall inspect the covers for sensor apertures or other devices that inhibit the operation of sensors to confirm that they are in their proper position pursuant to Annex E, unless otherwise agreed by all States Parties involved.
11. In the event that the observation aircraft is provided by the observing Party, upon the arrival of the observation aircraft at the point of entry or at the Open Skies airfield where the observation flight commences, the observed Party shall have the right to carry out the pre-flight inspection pursuant to Annex F, Section I. In the event that, in accordance with paragraph 1 of this Section, an observation aircraft is provided by the observed Party, the observing Party shall have the right to carry out the pre-flight inspection of sensors pursuant to Annex F, Section II. Unless otherwise agreed, such inspections shall terminate no less than four hours prior to the scheduled commencement of the observation flight set forth in the flight plan.
12. The observing Party shall ensure that its flight crew includes at least one individual who has the necessary linguistic ability to communicate freely with the personnel of the observed Party and its air traffic control authorities in the language or languages notified by the observed Party in accordance with paragraph 4 of this Section.
13. The observed Party shall provide the flight crew, upon its arrival at the point of entry or at the Open Skies airfield where the observation flight commences, with the most recent weather forecast and air navigation information and information on flight safety, including Notices to Airmen. Updates of such information shall be provided as requested. Instrument procedures, and information about alternate airfields along the flight route, shall be provided upon approval of the mission plan in accordance with the requirements of Section II of this Article.
14. While conducting observation flights pursuant to this Treaty, all observation aircraft shall be operated in accordance with the provisions of this Treaty and in accordance with the approved flight plan. Without prejudice to the provisions of Section II, paragraph 2 of this Article, observation flights shall also be conducted in compliance with:
(A) published ICAO standards and recommended practices; and
(B) published national air traffic control rules, procedures and guidelines on flight safety of the State Party whose territory is being overflown.
15. Observation flights shall take priority over any regular air traffic. The observed Party shall ensure that its air traffic control authorities facilitate the conduct of observation flights in accordance with this Treaty.
16. On board the aircraft the pilot-in-command shall be the sole authority for the safe conduct of the flight and shall be responsible for the execution of the flight plan.
17. The observed Party shall provide:
(A) a calibration target suitable for confirming the capability of sensors in accordance with the procedures set forth in Annex D, Section III to this Treaty, to be overflown during the demonstration flight or the observation flight upon the request of either Party, for each sensor that is to be used during the observation flight. The calibration target shall be located in the vicinity of the airfield at which the pre-flight inspection is conducted pursuant to Annex F to this Treaty;
(B) customary commercial aircraft fuelling and servicing for the observation aircraft or transport aircraft at the point of entry, at the Open Skies airfield, at any refuelling airfield, and at the point of exit specified in the flight plan, according to the specifications that are published about the designated airfield;
(C) meals and the use of accommodation for the personnel of the observing Party; and
(D) upon the request of the observing Party, further services, as may be agreed upon between the observing and observed Parties, to facilitate the conduct of the observation flight.

18. All costs involved in the conduct of the observation flight, including the costs of the recording media and the processing of the data collected by sensors, shall be reimbursed in accordance with Annex L, Section I, paragraph 9 to this Treaty.
19. Prior to the departure of the observation aircraft from the point of exit, the observed Party shall confirm that the covers for sensor apertures or other devices that inhibit the operation of sensors are in their proper position pursuant to Annex E to this Treaty.
20. Unless otherwise agreed, the observing Party shall depart from the point of exit no later than 24 hours following completion of the observation flight, unless weather conditions or the airworthiness of the observation aircraft or transport aircraft do not permit, in which case the flight shall commence as soon as practicable.
21. The observing Party shall compile a mission report of the observation flight using the appropriate format developed by the Open Skies Consultative Commission. The mission report shall contain pertinent data on the date and time of the observation flight, its route and profile, weather conditions, time and location of each observation period for each sensor, the approximate amount of data collected by sensors, and the result of inspection of covers for sensor apertures or other devices that inhibit the operation of sensors in accordance with Article VII and Annex E. The mission report shall be signed by the observing and observed Parties at the point of exit and shall be provided by the observing Party to all other States Parties within seven days after departure of the observing Party from the point of exit.

SECTION II. REQUIREMENTS FOR MISSION PLANNING

1. Unless otherwise agreed, the observing Party shall, after arrival at the Open Skies airfield, submit to the observed Party a mission plan for the proposed observation flight that meets the requirements of paragraphs 2 and 4 of this Section.
2. The mission plan may provide for an observation flight that allows for the observation of any point on the entire territory of the observed Party, including areas designated by the observed Party as hazardous airspace in the source specified in Annex I. The flight path of an observation aircraft shall not be closer than, but shall be allowed up to, ten kilometres from the border with an adjacent State that is not a State Party.
3. The mission plan may provide that the Open Skies airfield where the observation flight terminates, as well as the point of exit, may be different from the Open Skies airfield where the observation flight commences or the point of entry. The mission plan shall specify, if applicable, the commencement time of the observation flight, the desired time and place of planned refuelling stops or rest periods, and the time of continuation of the observation flight after a refuelling stop or rest period within the 96-hour period specified in Section I, paragraph 9 of this Article.
4. The mission plan shall include all information necessary to file the flight plan and shall provide that:
(A) the observation flight does not exceed the relevant maximum flight distance as set forth in Annex A, Section I;
(B) the route and profile of the observation flight satisfies observation flight safety conditions in conformity with ICAO standards and recommended practices, taking into account existing differences in national flight rules, without prejudice to the provisions of paragraph 2 of this Section;
(C) the mission plan takes into account information on hazardous airspace, as provided in accordance with Annex I;
(D) the height above ground level of the observation aircraft does not permit the observing Party to exceed the limitation on ground resolution for each sensor, as set forth in Article IV, paragraph 2;
(E) the estimated time of commencement of the observation flight shall be no less than 24 hours after the submission of the mission plan, unless otherwise agreed;
(F) the observation aircraft flies a direct route between the co-ordinates or navigation fixes designated in the mission plan in the declared sequence; and
(G) the flight path does not intersect at the same point more than once, unless otherwise agreed, and the observation aircraft does not circle around a single point, unless otherwise agreed. The provisions of this subparagraph do not apply for the purposes of

taking off, flying over calibration targets, or landing by the observation aircraft.

5. In the event that the mission plan filed by the observing Party provides for flights through hazardous airspace, the observed Party shall:
   (A) specify the hazard to the observation aircraft;
   (B) facilitate the conduct of the observation flight by co-ordination or suppression of the activity specified pursuant to subparagraph (A) of this paragraph; or
   (C) propose an alternative flight altitude, route, or time.
6. No later than four hours after submission of the mission plan, the observed Party shall accept the mission plan or propose changes to it in accordance with Article VIII, Section I, paragraph 4 and paragraph 5 of this Section. Such changes shall not preclude observation of any point on the entire territory of the observed Party, including areas designated by the observed Party as hazardous airspace in the source specified in Annex I to this Treaty. Upon agreement, the mission plan shall be signed by the observing and observed Parties. In the event that the Parties do not reach agreement on the mission plan within eight hours of the submission of the original mission plan, the observing Party shall have the right to decline to conduct the observation flight in accordance with the provisions of Article VIII of this Treaty.
7. If the planned route of the observation flight approaches the border of other States Parties or other States, the observed Party may notify that State or those States of the estimated route, date and time of the observation flight.
8. On the basis of the agreed mission plan the State Party providing the observation aircraft shall, in co-ordination with the other State Party, file the flight plan immediately, which shall have the content specified in Annex 2 to the Convention on International Civil Aviation and shall be in the format specified by ICAO Document No. 4444-RAC/501/12, "Rules of the Air and Air Traffic Services", as revised or amended.

SECTION III. SPECIAL PROVISIONS

1. In the event that the observation aircraft is provided by the observing Party, the observed Party shall have the right to have on board the observation aircraft two flight monitors and one interpreter, in addition to one flight monitor for each sensor control station on board the observation aircraft, unless otherwise agreed. Flight monitors and interpreters shall have the rights and obligations specified in Annex G to this Treaty.
2. Notwithstanding paragraph 1 of this Section, in the event that an observing Party uses an observation aircraft which has a maximum take-off gross weight of no more than 35,000 kilograms for an observation flight distance of no more than 1,500 kilometres as notified in accordance with Section I, paragraph 5, subparagraph (G) of this Article, it shall be obliged to accept only two flight monitors and one interpreter on board the observation aircraft, unless otherwise agreed.
3. In the event that the observation aircraft is provided by the observed Party, the observed Party shall permit the personnel of the observing Party to travel to the point of entry of the observed Party in the most expeditious manner. The personnel of the observing Party may elect to travel to the point of entry using ground, sea, or air transportation, including transportation by an aircraft owned by any State Party. Procedures regarding such travel are set forth in Annex E to this Treaty.
4. In the event that the observation aircraft is provided by the observed Party, the observing Party shall have the right to have on board the observation aircraft two flight representatives and one interpreter, in addition to one flight representative for each sensor control station on the aircraft, unless otherwise agreed. Flight representatives and interpreters shall have the rights and obligations set forth in Annex G to this Treaty.
5. In the event that the observing State Party provides an observation aircraft designated by a State Party other than the observing or observed Party, the observing Party shall have the right to have on board the observation aircraft two representatives and one interpreter, in addition to one representative for each sensor control station on the aircraft, unless otherwise agreed. In this case, the provisions on flight monitors set forth in paragraph 1 of this Section shall also apply. Representatives and interpreters shall have the rights and obligations set forth in Annex G to this Treaty.

ARTICLE VII: TRANSIT FLIGHTS

1. Transit flights conducted by an observing Party to and from the territory of an observed Party for the purposes of this Treaty shall originate on the territory of the observing Party or of another State Party.
2. Each State Party shall accept transit flights. Such transit flights shall be conducted along internationally recognized Air Traffic Services routes, unless otherwise agreed by the States Parties involved, and in accordance with the instructions of the national air traffic control authorities of each State Party whose airspace is transited. The observing Party shall notify each State Party whose airspace is to be transited at the same time that it notifies the observed Party in accordance with Article VI.
3. The operation of sensors on an observation aircraft during transit flights is prohibited. In the event that, during the transit flight, the observation aircraft lands on the territory of a State Party, that State Party shall, upon landing and prior to departure, inspect the covers of sensor apertures or other devices that inhibit the operation of sensors to confirm that they are in their proper position.

ARTICLE VIII: PROHIBITIONS, DEVIATIONS FROM FLIGHT PLANS AND EMERGENCY SITUATIONS

SECTION I. PROHIBITION OF OBSERVATION FLIGHTS AND CHANGES TO MISSION PLANS

1. The observed Party shall have the right to prohibit an observation flight that is not in compliance with the provisions of this Treaty.
2. The observed Party shall have the right to prohibit an observation flight prior to its commencement in the event that the observing Party fails to arrive at the point of entry within 24 hours after the estimated time of arrival specified in the notification provided in accordance with Article VI, Section I, paragraph 5, unless otherwise agreed between the States Parties involved.
3. In the event that an observed State Party prohibits an observation flight pursuant to this Article or Annex F, it shall immediately state the facts for the prohibition in the mission plan. Within seven days the observed Party shall provide to all States Parties, through diplomatic channels, a written explanation for this prohibition in the mission report provided pursuant to Article VI, Section I, paragraph 21. An observation flight that has been prohibited shall not be counted against the quota of either State Party.
4. The observed Party shall have the right to propose changes to the mission plan as a result of any of the following circumstances:
   (A) the weather conditions affect flight safety;
   (B) the status of the Open Skies airfield to be used, alternate airfields, or refuelling airfields prevents their use; or
   (C) the mission plan is inconsistent with Article VI, Section II, paragraphs 2 and 4.
5. In the event that the observing Party disagrees with the proposed changes to the mission plan, it shall have the right to submit alternatives to the proposed changes. In the event that agreement on a mission plan is not reached within eight hours of the submission of the original mission plan, and if the observing Party considers the changes to the mission plan to be prejudicial to its rights under this Treaty with respect to the conduct of the observation flight, the observing Party shall have the right to decline to conduct the observation flight, which shall not be recorded against the quota of either State Party.
6. In the event that an observing Party declines to conduct an observation flight pursuant to this Article or Annex F, it shall immediately provide an explanation of its decision in the mission plan prior to the departure of the observing Party. Within seven days after departure of the observing Party, the observing Party shall provide to all other States Parties, through diplomatic channels, a written explanation for this decision in the mission report provided pursuant to Article VI, Section I, paragraph 21.

SECTION II. DEVIATIONS FROM THE FLIGHT PLAN

1. Deviations from the flight plan shall be permitted during the observation flight if necessitated by:
   (A) weather conditions affecting flight safety;

(B) technical difficulties relating to the observation aircraft;
(C) a medical emergency of any person on board; or
(D) air traffic control instructions related to circumstances brought about by *force majeure.*

2. In addition, if weather conditions prevent effective use of optical sensors and infra-red line-scanning devices, deviations shall be permitted, provided that:
(A) flight safety requirements are met;
(B) in cases where national rules so require, permission is granted by air traffic control authorities; and
(C) the performance of the sensors does not exceed the capabilities specified in Article IV, paragraph 2, unless otherwise agreed.
3. The observed Party shall have the right to prohibit the use of a particular sensor during a deviation that brings the observation aircraft below the minimum height above ground level for operating that particular sensor, in accordance with the limitation on ground resolution specified in Article IV, paragraph 2. In the event that a deviation requires the observation aircraft to alter its flight path by more than 50 kilometres from the flight path specified in the flight plan, the observed Party shall have the right to prohibit the use of all the sensors installed on the observation aircraft beyond that 50-kilometre limit.
4. The observing Party shall have the right to curtail an observation flight during its execution in the event of sensor malfunction. The pilot-in-command shall have the right to curtail an observation flight in the event of technical difficulties affecting the safety of the observation aircraft.
5. In the event that a deviation from the flight plan permitted by paragraph 1 of this Section results in curtailment of the observation flight, or a curtailment occurs in accordance with paragraph 4 of this Section, an observation flight shall be counted against the quotas of both States Parties, unless the curtailment is due to:
(A) sensor malfunction on an observation aircraft provided by the observed Party;
(B) technical difficulties relating to the observation aircraft provided by the observed Party;
(C) a medical emergency of a member of the flight crew of the observed Party or of flight monitors; or
(D) air traffic control instructions related to circumstances brought about by force majeure.
In such cases the observing Party shall have the right to decide whether to count it against the quotas of both States Parties.
6. The data collected by the sensors shall be retained by the observing Party only if the observation flight is counted against the quotas of both States Parties.
7. In the event that a deviation is made from the flight plan, the pilot-in-command shall take action in accordance with the published national flight regulations of the observed Party. Once the factors leading to the deviation have ceased to exist, the observation aircraft may, with the permission of the air traffic control authorities, continue the observation flight in accordance with the flight plan. The additional flight distance of the observation aircraft due to the deviation shall not count against the maximum flight distance.
8. Personnel of both States Parties on board the observation aircraft shall be immediately informed of all deviations from the flight plan.
9. Additional expenses resulting from provisions of this Article shall be reimbursed in accordance with Annex L, Section I, paragraph 9 to this Treaty.

SECTION III. EMERGENCY SITUATIONS

1. In the event that an emergency situation arises, the pilot-in-command shall be guided by "Procedures for Air Navigation Services - Rules of the Air and Air Traffic Services", ICAO Document No. 4444-RAC/501/12, as revised or amended, the national flight regulations of the observed Party, and the flight operation manual of the observation aircraft.
2. Each observation aircraft declaring an emergency shall be accorded the full range of distress and navigational facilities of the observed Party in order to ensure the most expeditious recovery of the aircraft to the nearest suitable airfield.
3. In the event of an aviation accident involving the observation aircraft on the territory of the observed Party, search and rescue operations shall be conducted by the observed Party in accordance with its own regulations and procedures for such operations.

4. Investigation of an aviation accident or incident involving an observation aircraft shall be conducted by the observed Party, with the participation of the observing Party, in accordance with the ICAO recommendations set forth in Annex 13 to the Convention on International Civil Aviation ("Investigation of Aviation Accidents") as revised or amended and in accordance with the national regulations of the observed Party.
5. In the event that the observation aircraft is not registered with the observed Party, at the conclusion of the investigation all wreckage and debris of the observation aircraft and sensors, if found and recovered, shall be returned to the observing Party or to the Party to which the aircraft belongs, if so requested.

ARTICLE IX: SENSOR OUTPUT FROM OBSERVATION FLIGHTS

SECTION I. GENERAL PROVISIONS

1. For the purposes of recording data collected by sensors during observation flights, the following recording media shall be used:
   (A) in the case of optical panoramic and framing cameras, black and white photographic film;
   (B) in the case of video cameras, magnetic tape;
   (C) in the case of infra-red line-scanning devices, black and white photographic film or magnetic tape; and
   (D) in the case of sideways-looking synthetic aperture radar, magnetic tape.
   The agreed format in which such data is to be recorded and exchanged on other recording media shall be decided within the Open Skies Consultative Commission during the period of provisional application of this Treaty.
2. Data collected by sensors during observation flights shall remain on board the observation aircraft until completion of the observation flight. The transmission of data collected by sensors from the observation aircraft during the observation flight is prohibited.
3. Each roll of photographic film and cassette or reel of magnetic tape used to collect data by a sensor during an observation flight shall be placed in a container and sealed in the presence of the States Parties as soon as is practicable after it has been removed from the sensor.
4. Data collected by sensors during observation flights shall be made available to States Parties in accordance with the provisions of this Article and shall be used exclusively for the attainment of the purposes of this Treaty.
5. In the event that, on the basis of data provided pursuant to Annex B, Section I to this Treaty, a data recording medium to be used by a State Party during an observation flight is incompatible with the equipment of another State Party for handling that data recording medium, the States Parties involved shall establish procedures to ensure that all data collected during observation flights can be handled, in terms of processing, duplication and storage, by them.

SECTION II. OUTPUT FROM SENSORS THAT USE PHOTOGRAPHIC FILM

1. In the event that output from duplicate optical cameras is to be exchanged, the cameras, film and film processing shall be of an identical type.
2. Provided that the data collected by a single optical camera is subject to exchange, the States Parties shall consider, within the Open Skies Consultative Commission during the period of provisional application of this Treaty, the issue of whether the responsibility for the development of the original film negative shall be borne by the observing Party or by the State Party providing the observation aircraft. The State Party developing the original film negative shall be responsible for the quality of processing the original negative film and producing the duplicate positive or negative. In the event that States Parties agree that the film used during the observation flight conducted on an observation aircraft provided by the observed Party shall be processed by the observing Party, the observed Party shall bear no responsibility for the quality of the processing of the original negative film.
3. All the film used during the observation flight shall be developed:
   (A) in the event that the original film negative is developed at a film processing facility arranged for by the observed Party, no later

than three days, unless otherwise agreed, after the arrival of the observation aircraft at the point of exit; or
(B) in the event that the original film negative is developed at a film processing facility arranged for by the observing Party, no later than ten days after the departure of the observation aircraft from the territory of the observed Party.

4. The State Party that is developing the original film negative shall be obliged to accept at the film processing facility up to two officials from the other State Party to monitor the unsealing of the film cassette or container and each step in the storage, processing, duplication and handling of the original film negative, in accordance with the provisions of Annex K, Section II to this Treaty. The State Party monitoring the film processing and duplication shall have the right to designate such officials from among its nationals present on the territory on which the film processing facility arranged for by the other State Party is located, provided that such individuals are on the list of designated personnel in accordance with Article XIII, Section I of this Treaty. The State Party developing the film shall assist the officials of the other State Party in their functions provided for in this paragraph to the maximum extent possible.
5. Upon completion of an observation flight, the State Party that is to develop the original film negative shall attach a 21-step sensitometric test strip of the same film type used during the observation flight or shall expose a 21-step optical wedge onto the leader or trailer of each roll of original film negative used during the observation flight. After the original film negative has been processed and duplicate film negative or positive has been produced, the States Parties shall assess the image quality of the 21-step sensitometric test strips or images of the 21-step optical wedge against the characteristics provided for that type of original film negative or duplicate film negative or positive in accordance with the provisions of Annex K, Section I to this Treaty.
6. In the event that only one original film negative is developed:
(A) the observing Party shall have the right to retain or receive the original film negative; and
(B) the observed Party shall have the right to select and receive a complete first generation duplicate or part thereof, either positive or negative, of the original film negative. Unless otherwise agreed, such duplicate shall be:
    1. of the same format and film size as the original film negative;
    2. produced immediately after development of the original film negative; and
    3. provided to the officials of the observed Party immediately after the duplicate has been produced.
7. In the event that two original film negatives are developed:
(A) if the observation aircraft is provided by the observing Party, the observed Party shall have the right, at the completion of the observation flight, to select either of the two original film negatives, and the original film negative not selected shall be retained by the observing Party; or
(B) if the observation aircraft is provided by the observed Party, the observing Party shall have the right to select either of the original film negatives, and the original film negative not selected shall be retained by the observed Party.

SECTION III. OUTPUT FROM SENSORS THAT USE OTHER RECORDING MEDIA

1. The State Party that provides the observation aircraft shall record at least one original set of data collected by sensors using other recording media.
2. In the event that only one original set is made:
(A) if the observation aircraft is provided by the observing Party, the observing Party shall have the right to retain the original set and the observed Party shall have the right to receive a first generation duplicate copy; or
(B) if the observation aircraft is provided by the observed Party, the observing Party shall have the right to receive the original set and the observed Party shall have the right to receive a first generation duplicate copy.
3. In the event that two original sets are made:
(A) if the observation aircraft is provided by the observing Party, the observed Party shall have the right, at the completion of the observation flight, to select either of the two sets of recording media, and the set not selected shall be retained by the observing Party; or
(B) if the observation aircraft is provided by the observed Party, the observing Party shall

have the right to select either of the two sets of recording media, and the set not selected shall be retained by the observed Party.

4. In the event that the observation aircraft is provided by the observing Party, the observed Party shall have the right to receive the data collected by a sideways-looking synthetic aperture radar in the form of either initial phase information or a radar image, at its choice.
5. In the event that the observation aircraft is provided by the observed Party, the observing Party shall have the right to receive the data collected by a sideways-looking synthetic aperture radar in the form of either initial phase information or a radar image, at its choice.

SECTION IV. ACCESS TO SENSOR OUTPUT

Each State Party shall have the right to request and receive from the observing Party copies of data collected by sensors during an observation flight. Such copies shall be in the form of first generation duplicates produced from the original data collected by sensors during an observation flight. The State Party requesting copies shall also notify the observed Party. A request for duplicates of data shall include the following information:

(A) the observing Party;
(B) the observed Party;
(C) the date of the observation flight;
(D) the sensor by which the data was collected;
(E) the portion or portions of the observation period during which the data was collected; and
(F) the type and format of duplicate recording medium, either negative or positive film, or magnetic tape.

ARTICLE X: OPEN SKIES CONSULTATIVE COMMISSION

1. In order to promote the objectives and facilitate the implementation of the provisions of this Treaty, the States Parties hereby establish an Open Skies Consultative Commission.
2. The Open Skies Consultative Commission shall take decisions or make recommendations by consensus. Consensus shall be understood to mean the absence of any objection by any State Party to the taking of a decision or the making of a recommendation.
3. Each State Party shall have the right to raise before the Open Skies Consultative Commission, and have placed on its agenda, any issue relating to this Treaty, including any issue related to the case when the observed Party provides an observation aircraft.
4. Within the framework of the Open Skies Consultative Commission the States Parties to this Treaty shall:
(A) consider questions relating to compliance with the provisions of this Treaty;
(B) seek to resolve ambiguities and differences of interpretation that may become apparent in the way this Treaty is implemented;
(C) consider and take decisions on applications for accession to this Treaty; and
(D) agree as to those technical and administrative measures, pursuant to the provisions of this Treaty, deemed necessary following the accession to this Treaty by other States.
5. The Open Skies Consultative Commission may propose amendments to this Treaty for consideration and approval in accordance with Article XVI. The Open Skies Consultative Commission may also agree on improvements to the viability and effectiveness of this Treaty, consistent with its provisions. Improvements relating only to modification of the annual distribution of active quotas pursuant to Article III and Annex A, to updates and additions to the categories or capabilities of sensors pursuant to Article IV, to revision of the share of costs pursuant to Annex L, Section I, paragraph 9, to arrangements for the sharing and availability of data pursuant to Article IX, Sections III and IV and to the handling of mission reports pursuant to Article VI, Section I, paragraph 21, as well as to minor matters of an administrative or technical nature, shall be agreed upon within the Open Skies Consultative Commission and shall not be deemed to be amendments to this Treaty.
6. The Open Skies Consultative Commission shall request the use of the facilities and administrative support of the Conflict Prevention Centre of the Conference on Security and Co-operation in Europe, or other existing facilities in Vienna, unless it decides otherwise.
7. Provisions for the operation of the Open Skies Consultative Commission are set forth in Annex L to this Treaty.

ARTICLE XI: NOTIFICATIONS AND REPORTS

The States Parties shall transmit notifications and reports required by this Treaty in written form. The States Parties shall transmit such notifications and reports through diplomatic channels or, at their choice, through other official channels, such as the communications network of the Conference on Security and Co-operation in Europe.

ARTICLE XII: LIABILITY

A State Party shall, in accordance with international law and practice, be liable to pay compensation for damage to other States Parties, or to their natural or juridical persons or their property, caused by it in the course of the implementation of this Treaty.

ARTICLE XIII: DESIGNATION OF PERSONNEL AND PRIVILEGES AND IMMUNITIES

SECTION I. DESIGNATION OF PERSONNEL

1. Each State Party shall, at the same time that it deposits its instrument of ratification to either of the Depositaries, provide to all other States Parties, for their review, a list of designated personnel who will carry out all duties relating to the conduct of observation flights for that State Party, including monitoring the processing of the sensor output. No such list of designated personnel shall include more than 400 individuals at any time. It shall contain the name, gender, date of birth, place of birth, passport number, and function for each individual included. Each State Party shall have the right to amend its list of designated personnel until 30 days after entry into force of this Treaty and once every six months thereafter.
2. In the event that any individual included on the original or any amended list is unacceptable to a State Party reviewing the list, that State Party shall, no later than 30 days after receipt of each list, notify the State Party providing that list that such individual shall not be accepted with respect to the objecting State Party. Individuals not declared unacceptable within that 30-day period shall be deemed accepted. In the event that a State Party subsequently determines that an individual is unacceptable, that State Party shall so notify the State Party that designated such individual. Individuals who are declared unacceptable shall be removed from the list previously submitted to the objecting State Party.
3. The observed Party shall provide visas and any other documents as required to ensure that each accepted individual may enter and remain on the territory of that State Party for the purpose of carrying out duties relating to the conduct of observation flights, including monitoring the processing of the sensor output. Such visas and any other necessary documents shall be provided either:
   (A) no later than 30 days after the individual is deemed to be accepted, in which case the visa shall be valid for a period of no less than 24 months; or
   (B) no later than one hour after the arrival of the individual at the point of entry, in which case the visa shall be valid for the duration of that individual?s duties; or
   (C) at any other time, by mutual agreement of the States Parties involved.

SECTION II. PRIVILEGES AND IMMUNITIES

1. In order to exercise their functions effectively, for the purpose of implementing this Treaty and not for their personal benefit, personnel designated in accordance with the provisions of Section I, paragraph 1 of this Article shall be accorded the privileges and immunities enjoyed by diplomatic agents pursuant to Article 29; Article 30, paragraph 2; Article 31, paragraphs 1, 2 and 3; and Articles 34 and 35 of the Vienna Convention on Diplomatic Relations of 18 April 1961, hereinafter referred to as the Vienna Convention. In addition, designated personnel shall be accorded the privileges enjoyed by diplomatic agents pursuant to Article 36, paragraph 1, subparagraph (b) of the Vienna Convention, except in relation to articles, the import or export of which is prohibited by law or controlled by quarantine regulations.
2. Such privileges and immunities shall be accorded to designated personnel for the entire period between arrival on and departure from the territory of the observed Party, and thereafter with respect to acts

previously performed in the exercise of their official functions. Such personnel shall also, when transiting the territory of other States Parties, be accorded the privileges and immunities enjoyed by diplomatic agents pursuant to Article 40, paragraph 1 of the Vienna Convention.

3. The immunity from jurisdiction may be waived by the observing Party in those cases when it would impede the course of justice and can be waived without prejudice to this Treaty. The immunity of personnel who are not nationals of the observing Party may be waived only by the States Parties of which such personnel are nationals. Waiver must always be express.
4. Without prejudice to their privileges and immunities or the rights of the observing Party set forth in this Treaty, it is the duty of designated personnel to respect the laws and regulations of the observed Party.
5. The transportation means of the personnel shall be accorded the same immunities from search, requisition, attachment or execution as those of a diplomatic mission pursuant to Article 22, paragraph 3 of the Vienna Convention, except as otherwise provided for in this Treaty.

ARTICLE XIV: BENELUX

1. Solely for the purposes of Articles II to IX and Article XI, and of Annexes A to I and Annex K to this Treaty, the Kingdom of Belgium, the Grand Duchy of Luxembourg, and the Kingdom of the Netherlands shall be deemed a single State Party, hereinafter referred to as the Benelux.
2. Without prejudice to the provisions of Article XV, the above-mentioned States Parties may terminate this arrangement by notifying all other States Parties thereof. This arrangement shall be deemed to be terminated on the next 31 December following the 60-day period after such notification.

ARTICLE XV: DURATION AND WITHDRAWAL

1. This Treaty shall be of unlimited duration.
2. A State Party shall have the right to withdraw from this Treaty. A State Party intending to withdraw shall provide notice of its decision to withdraw to either Depositary at least six months in advance of the date of its intended withdrawal and to all other States Parties. The Depositaries shall promptly inform all other States Parties of such notice.
3. In the event that a State Party provides notice of its decision to withdraw from this Treaty in accordance with paragraph 2 of this Article, the Depositaries shall convene a conference of the States Parties no less than 30 days and no more than 60 days after they have received such notice, in order to consider the effect of the withdrawal on this Treaty.

ARTICLE XVI: AMENDMENTS AND PERIODIC REVIEW

1. Each State Party shall have the right to propose amendments to this Treaty. The text of each proposed amendment shall be submitted to either Depositary, which shall circulate it to all States Parties for consideration. If so requested by no less than three States Parties within a period of 90 days after circulation of the proposed amendment, the Depositaries shall convene a conference of the States Parties to consider the proposed amendment. Such a conference shall open no earlier than 30 days and no later than 60 days after receipt of the third of such requests.
2. An amendment to this Treaty shall be subject to the approval of all States Parties, either by providing notification, in writing, of their approval to a Depositary within a period of 90 days after circulation of the proposed amendment, or by expressing their approval at a conference convened in accordance with paragraph 1 of this Article. An amendment so approved shall be subject to ratification in accordance with the provisions of Article XVII, paragraph 1, and shall enter into force 60 days after the deposit of instruments of ratification by the States Parties.
3. Unless requested to do so earlier by no less than three States Parties, the Depositaries shall convene a conference of the States Parties to review the implementation of this Treaty three years after entry into force of this Treaty and at five-year intervals thereafter.

ARTICLE XVII: DEPOSITARIES, ENTRY INTO FORCE AND ACCESSION

1. This Treaty shall be subject to ratification by each State Party in accordance with its constitutional procedures. Instruments of ratification and instruments of accession shall be deposited with the Government of Canada or the Government of the Republic of Hungary or both, hereby designated the Depositaries. This Treaty shall be registered by the Depositaries pursuant to Article 102 of the Charter of the United Nations.
2. This Treaty shall enter into force 60 days after the deposit of 20 instruments of ratification, including those of the Depositaries, and of States Parties whose individual allocation of passive quotas as set forth in Annex A is eight or more.
3. This Treaty shall be open for signature by Armenia, Azerbaijan, Georgia, Kazakhstan, Kirgistan, Moldova, Tajikistan, Turkmenistan and Uzbekistan and shall be subject to ratification by them. Any of these States which do not sign this Treaty before it enters into force in accordance with the provisions of paragraph 2 of this Article may accede to it at any time by depositing an instrument of accession with one of the Depositaries.
4. For six months after entry into force of this Treaty, any other State participating in the Conference on Security and Co-operation in Europe may apply for accession by submitting a written request to one of the Depositaries. The Depositary receiving such a request shall circulate it promptly to all States Parties. The States applying for accession to this Treaty may also, if they so wish, request an allocation of a passive quota and the level of this quota.
5. The matter shall be considered at the next regular meeting of the Open Skies Consultative Commission and decided in due course.
6. Following six months after entry into force of this Treaty, the Open Skies Consultative Commission may consider the accession to this Treaty of any State which, in the judgement of the Commission, is able and willing to contribute to the objectives of this Treaty.
7. For any State which has not deposited an instrument of ratification by the time of entry into force, but which subsequently ratifies or accedes to this Treaty, this Treaty shall enter into force 60 days after the date of deposit of its instrument of ratification or accession.
8. The Depositaries shall promptly inform all States Parties of:
   (A) the date of deposit of each instrument of ratification and the date of entry into force of this Treaty;
   (B) the date of an application for accession, the name of the requesting State and the result of the procedure;
   (C) the date of deposit of each instrument of accession and the date of entry into force of this Treaty for each State that subsequently accedes to it;
   (D) the convening of a conference pursuant to Articles XV and XVI;
   (E) any withdrawal in accordance with Article XV and its effective date;
   (F) the date of entry into force of any amendments to this Treaty; and
   (G) any other matters of which the Depositaries are required by this Treaty to inform the States Parties.

ARTICLE XVIII: PROVISIONAL APPLICATION AND PHASING OF IMPLEMENTATION OF THE TREATY

In order to facilitate the implementation of this Treaty, certain of its provisions shall be provisionally applied and others shall be implemented in phases.

SECTION I. PROVISIONAL APPLICATION

1. Without detriment to Article XVII, the signatory States shall provisionally apply the following provisions of this Treaty:
   (A) Article VI, Section I, paragraph 4;
   (B) Article X, paragraphs 1, 2, 3, 6 and 7;
   (C) Article XI;
   (D) Article XIII, Section I, paragraphs 1 and 2;
   (E) Article XIV; and
   (F) Annex L, Section I.
2. This provisional application shall be effective for a period of 12 months from the date when this Treaty is opened for signature. In the event that this Treaty does not enter into force before the period of provisional application expires, that period may be extended if all the signatory States so decide. The period of provisional application shall in any event terminate when this Treaty enters into force. However, the States Parties may then decide to

extend the period of provisional application in respect of signatory States that have not ratified this Treaty.

SECTION II. PHASING OF IMPLEMENTATION

1. After entry into force, this Treaty shall be implemented in phases in accordance with the provisions set forth in this Section. The provisions of paragraphs 2 to 6 of this Section shall apply during the period from entry into force of this Treaty until 31 December of the third year following the year during which entry into force takes place.
2. Notwithstanding the provisions of Article IV, paragraph 1, no State Party shall during the period specified in paragraph 1 above use an infra-red line-scanning device if one is installed on an observation aircraft, unless otherwise agreed between the observing and observed Parties. Such sensors shall not be subject to certification in accordance with Annex D. If it is difficult to remove such sensor from the observation aircraft, then it shall have covers or other devices that inhibit its operation in accordance with the provisions of Article IV, paragraph 4 during the conduct of observation flights.
3. Notwithstanding the provisions of Article IV, paragraph 9, no State Party shall, during the period specified in paragraph 1 of this Section, be obliged to provide an observation aircraft equipped with sensors from each sensor category, at the maximum capability and in the numbers specified in Article IV, paragraph 2, provided that the observation aircraft is equipped with:
   (A) a single optical panoramic camera; or
   (B) not less than a pair of optical framing cameras.
4. Notwithstanding the provisions of Annex B, Section II, paragraph 2, subparagraph (A) to this Treaty, data recording media shall be annotated with data in accordance with existing practice of States Parties during the period specified in paragraph 1 of this Section.
5. Notwithstanding the provisions of Article VI, Section I, paragraph 1, no State Party during the period specified in paragraph 1 of this Section shall have the right to be provided with an aircraft capable of achieving any specified unrefuelled range.
6. During the period specified in paragraph 1 of this Section, the distribution of active quotas shall be established in accordance with the provisions of Annex A, Section II, paragraph 2 to this Treaty.
7. Further phasing in respect of the introduction of additional categories of sensors or improvements to the capabilities of existing categories of sensors shall be addressed by the Open Skies Consultative Commission in accordance with the provisions of Article IV, paragraph 3 concerning such introduction or improvement.

ARTICLE XIX: AUTHENTIC TEXTS

The originals of this Treaty, of which the English, French, German, Italian, Russian and Spanish texts are equally authentic, shall be deposited in the archives of the Depositaries. Duly certified copies of this Treaty shall be transmitted by the Depositaries to all the States Parties.

ANNEX A
QUOTAS AND MAXIMUM FLIGHT DISTANCES
SECTION I. ALLOCATION OF PASSIVE QUOTAS

1. The allocation of individual passive quotas is set forth as follows and shall be effective only for those States Parties having ratified the Treaty:

For the Federal Republic of Germany	12
For the United States of America	42
For the Republic of Belarus and the Russian Federation group of States Parties	42
For Benelux	6
For the Republic of Bulgaria	4
For Canada	12
For the Kingdom of Denmark	6
For the Kingdom of Spain	4
For the French Republic	12
For the United Kingdom of Great Britain and Northern Ireland	12
For the Hellenic Republic	4
For the Republic of Hungary	4
For the Republic of Iceland	4
For the Italian Republic	12
For the Kingdom of Norway	7
For the Republic of Poland	6
For the Portuguese Republic	2
For Romania	6
For the Czech and Slovak Federal Republic	4
For the Republic of Turkey	12
For Ukraine	12

2. In the event that an additional State ratifies or accedes to the Treaty in accordance with the provisions of Article XVII and Article X, paragraph 4, subparagraph (C), and taking into account Article X, paragraph 4, subparagraph (D), an allocation of passive quotas to such a State shall be considered during the regular session of the Open Skies Consultative Commission following the date of deposit of its instrument of ratification or accession.

SECTION II. FIRST DISTRIBUTION OF ACTIVE QUOTAS FOR OBSERVATION FLIGHTS

[deleted]

SECTION III. MAXIMUM FLIGHT DISTANCES OF OBSERVATION FLIGHTS

The maximum flight distances of observation flights over the territories of observed Parties commencing from each Open Skies airfield are as follows:

The Federal Republic of Germany	
WUNSTORF	1,200 kilometres
LANDSBERG-LECH	1,200 kilometres
The United States of America	
WASHINGTON-DULLES	4,900 kilometres
TRAVIS AFB	4,000 kilometres
ELMENDORF AFB	3,000 kilometres
LINCOLN-MUNICIPAL	4,800 kilometres
The Republic of Belarus and the Russian Federation group of States Parties	
KUBINKA	5,000 kilometres
ULAN UDE	5,000 kilometres
VORKUTA	6,500 kilometres
MAGADAN	6,500 kilometres
Benelux	
ZAVENTEM/MELSBROEK	945 kilometres
The Republic of Bulgaria	
SOFIA	660 kilometres
BURGAS	660 kilometres
Canada	
OTTAWA	5,000 kilometres
IQALUIT	6,000 kilometres
YELLOWKNIFE	5,000 kilometres
The Kingdom of Denmark	
Metropolitan	800 kilometres
FAROE ISLANDS	250 kilometres
GREENLAND	5,600 kilometres
The Kingdom of Spain	
GETAFE	1,300 kilometres
GANDO	750 kilometres
VALENCIA	1,300 kilometres
VALLADOLID	1,300 kilometres
MORON	1,300 kilometres
The French Republic	
ORLEANS-BRICY	1,400 kilometres
NICE-COTE D?AZUR	800 kilometres
TOULOUSE-BLAGNAC	700 kilometres
The United Kingdom of Great Britain and Northern Ireland	
BRIZE NORTON	1,150 kilometres
SCAMPTON	1,150 kilometres
LEUCHARS	1,150 kilometres
with SCILLY ISLANDS	1,500 kilometres
with SHETLAND ISLANDS	1,500 kilometres
The Hellenic Republic	
THESSALONIKI	900 kilometres
ELEFSIS	900 kilometres
with CRETE, KARPATHOS, RHODES, KOS ISLANDS	1,100 kilometres
The Republic of Hungary	
BUDAPEST-FERIHEGY	860 kilometres
The Republic of Iceland 1,500 kilometres	
The Italian Republic	
MILANO-MALPENSA	1,130 kilometres
PALERMO-PUNTA RAISI	1,400 kilometres
The Kingdom of Norway	
OSLO-GARDERMOEN	1,700 kilometres
TROMSOE-LANGNES	1,700 kilometres
The Republic of Poland	
WARSZAWA-OKECIE	1,400 kilometres
The Portuguese Republic	
LISBOA	1,200 kilometres
Sta. MARIA	1,700 kilometres
PORTO SANTO	1,030 kilometres
Romania	
BUCHAREST-OTOPENI	900 kilometres
TIMISOARA	900 kilometres
BACAU	900 kilometres
The Czech and Slovak Federal Republic	
PRAHA	600 kilometres
BRATISLAVA	700 kilometres
KOSICE	400 kilometres
The Republic of Turkey	
ESKISEHIR	1,500 kilometres
DIYARBAKIR	1,500 kilometres
Ukraine	
BORISPOL	2,100 kilometres

[Additional annexes not included]

Treaty Between the United States of America and the Union of Soviet Socialist Republics on Underground Nuclear Explosions for Peaceful Purposes

Signed at Washington and Moscow May 28, 1976
Entered into force December 11, 1990

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Proceeding from a desire to implement Article III of the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Underground Nuclear Weapon Tests, which calls for the earliest possible conclusion of an agreement on underground nuclear explosions for peaceful purposes,

Reaffirming their adherence to the objectives and principles of the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water, the Treaty on Non-Proliferation of Nuclear Weapons, and the Treaty on the Limitation of Underground Nuclear Weapon Tests, and their determination to observe strictly the provisions of these international agreements,

Desiring to assure that underground nuclear explosions for peaceful purposes shall not be used for purposes related to nuclear weapons,

Desiring that utilization of nuclear energy be directed only toward peaceful purposes,

Desiring to develop appropriately cooperation in the field of underground nuclear explosions for peaceful purposes,

Have agreed as follows:

ARTICLE I

1. The Parties enter into this Treaty to satisfy the obligations in Article III of the Treaty on the Limitation of Underground Nuclear Weapon Tests, and assume additional obligations in accordance with the provisions of this Treaty.
2. This Treaty shall govern all underground nuclear explosions for peaceful purposes conducted by the Parties after March 31, 1976.

ARTICLE II

For the purposes of this Treaty:

(a) "explosion" means any individual or group underground nuclear explosion for peaceful purposes;
(b) "explosive" means any device, mechanism or system for producing an individual explosion;
(c) "group explosion" means two or more individual explosions for which the time interval between successive individual explosions does not exceed five seconds and for which the emplacement points of all explosives can be interconnected by straight line segments, each of which joins two emplacement points and each of which does not exceed 40 kilometers.

ARTICLE III

1. Each Party, subject to the obligations assumed under this Treaty and other international agreements, reserves the right to:
   (a) carry out explosions at any place under its jurisdiction or control outside the geographical boundaries of test sites specified under the provisions of the Treaty on the Limitation of Underground Nuclear Weapon Tests; and
   (b) carry out, participate or assist in carrying out explosions in the territory of another State at the request of such other State.
2. Each Party undertakes to prohibit, to prevent and not to carry out at any place under its jurisdiction or control, and further undertakes not to carry out, participate or assist in carrying out anywhere:
   (a) any individual explosion having a yield exceeding 150 kilotons;
   (b) any group explosion:
      (1) having an aggregate yield exceeding 150 kilotons except in ways that will permit identification of each individual explosion and determination of the yield of each individual explosion in the group in accordance with the provisions of Article IV of and the Protocol to this Treaty;
      (2) having an aggregate yield exceeding one and one-half megatons;
   (c) any explosion which does not carry out a peaceful application;
   (d) any explosion except in compliance with the provisions of the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water, the Treaty on the Non-Proliferation of Nuclear Weapons, and other international agreements entered into by that Party.
3. The question of carrying out any individual explosion having a yield exceeding the yield

specified in paragraph 2(a) of this article will be considered by the Parties at an appropriate time to be agreed.

ARTICLE IV

1. For the purpose of providing assurance of compliance with the provisions of this Treaty, each Party shall:
   (a) use national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law; and
   (b) provide to the other Party information and access to sites of explosions and furnish assistance in accordance with the provisions set forth in the Protocol to this Treaty.
2. Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph 1(a) of this article, or with the implementation of the provisions of paragraph 1(b) of this article.

ARTICLE V

1. To promote the objectives and implementation of the provisions of this Treaty, the Parties shall establish promptly a Joint Consultative Commission within the framework of which they will:
   (a) consult with each other, make inquiries and furnish information in response to such inquiries, to assure confidence in compliance with the obligations assumed;
   (b) consider questions concerning compliance with the obligations assumed and related situations which may be considered ambiguous;
   (c) consider questions involving unintended interference with the means for assuring compliance with the provisions of this Treaty;
   (d) consider changes in technology or other new circumstances which have a bearing on the provisions of this Treaty; and
   (e) consider possible amendments to provisions governing underground nuclear explosions for peaceful purposes.
2. The Parties through consultation shall establish, and may amend as appropriate, Regulations for the Joint Consultative Commission governing procedures, composition and other relevant matters.

ARTICLE VI

1. The Parties will develop cooperation on the basis of mutual benefit, equality, and reciprocity in various areas related to carrying out underground nuclear explosions for peaceful purposes.
2. The Joint Consultative Commission will facilitate this cooperation by considering specific areas and forms of cooperation which shall be determined by agreement between the Parties in accordance with their constitutional procedures.
3. The Parties will appropriately inform the International Atomic Energy Agency of results of their cooperation in the field of underground nuclear explosions for peaceful purposes.

ARTICLE VII

1. Each Party shall continue to promote the development of the international agreement or agreements and procedures provided for in Article V of the Treaty on the Non-Proliferation of Nuclear Weapons, and shall provide appropriate assistance to the International Atomic Energy Agency in this regard.
2. Each Party undertakes not to carry out, participate or assist in the carrying out of any explosion in the territory of another State unless that State agrees to the implementation in its territory of the international observation and procedures contemplated by Article V of the Treaty on the Non-Proliferation of Nuclear Weapons and the provisions of Article IV of and the Protocol to this Treaty, including the provision by that State of the assistance necessary for such implementation and of the privileges and immunities specified in the Protocol.

ARTICLE VIII

1. This Treaty shall remain in force for a period of five years, and it shall be extended for

successive five-year periods unless either Party notifies the other of its termination no later than six months prior to its expiration. Before the expiration of this period the Parties may, as necessary, hold consultations to consider the situation relevant to the substance of this Treaty. However, under no circumstances shall either Party be entitled to terminate this Treaty while the Treaty on the Limitation of Underground Nuclear Weapon Tests remains in force.

2. Termination of the Treaty on the Limitation of Underground Nuclear Weapon Tests shall entitle either Party to withdraw from this Treaty at any time.
3. Each Party may propose amendments to this Treaty. Amendments shall enter into force on the day of the exchange of instruments of ratification of such amendments.

ARTICLE IX

1. This Treaty, including the Protocol which forms an integral part hereof, shall be subject to ratification in accordance with the constitutional procedures of each Party. This Treaty shall enter into force on the day of the exchange of instruments of ratification which exchange shall take place simultaneously with the exchange of instruments of ratification of the Treaty on the Limitation of Underground Nuclear Weapon Tests.
2. This Treaty shall be registered pursuant to Article 102 of the Charter of the United Nations.

DONE at Washington and Moscow, on May 28, 1976, in duplicate, in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES OF AMERICA:

GERALD R. FORD

The President of the United States of America

FOR THE UNION OF SOVIET SOCIALIST REPUBLICS:

L. BREZHNEV

General Secretary of the Central Committee of the CPSU

Agreement Between the Government of the United States of America and the Government of the Russian Federation Concerning Cooperation Regarding Plutonium Production Reactors

The Government of the United States of America and the Government of the Russian Federation, hereinafter referred to as the *Parties*

Expressing their desire to cooperate with each other to elaborate measures designed to prevent the accumulation of excessive stocks of plutonium and to reduce them in the future;

Taking into account the intent of the Government of the Russian Federation to take out of operation three presently operating reactors that produce plutonium and that provide heat and electricity to regions where they are located, and to create alternative sources of heat and electricity;

Taking into account the shutdown by the United States of America of all of its plutonium production reactors as of 1989;

Have agreed as follows:

ARTICLE I

1. All reactors listed in Annex I to this Agreement, which is an integral part of this Agreement, have ceased operations. These reactors shall not resume operation.
2. All reactors listed in Annex II to this Agreement, which is an integral part of this Agreement, shall cease by December 31, 2000, their production of non-reactor-grade plutonium by undergoing modification. After the completion of modifications, these reactors shall permanently cease operation at the end of their normal lifetime, consistent with prudent safety considerations.

ARTICLE II

1. The U.S. Party shall provide, subject to the availability of appropriated funds for this purpose, and subject to the Agreement between the Department of Defense of the United States of America and the Ministry of the Russian Federation for Atomic Energy Concerning the Modification of the Operating Seversk (Tomsk Region) and Zheleznogorsk

(Krasnoyarsk Region) Plutonium Production Reactors, which will be governed as specified in Article 1, paragraph 4, of that agreement and overseen as specified in Article VI of that agreement, step-by-step funding for cooperative implementation of the reactor modifications specified in Article I, paragraph 2, of this Agreement.

2. Provision of funds as described in paragraph 1 of this Article will be based on the achievement of cooperation project milestones to be agreed between the U.S. Party and the Russian Party. In the event that the Russian Party should fail to achieve an agreed cooperation project milestone or the U.S. Party should fail to provide an agreed level of assistance, including funding, to support an agreed cooperation project milestone, either Party may request consultations to determine how best to achieve the objectives of this Agreement under those circumstances. These consultations shall begin within 30 days of such a request. If after ISO days from the beginning of consultations, the Parties do not reach agreement, each Party shall have the right to suspend, until such agreement is achieved, implementation of this Agreement by sending the other Party, through diplomatic channels, appropriate written notification. The consultations specified in this paragraph shall continue until agreement is reached or, if this is not possible, until the termination of this Agreement, using the procedures provided for in Article XI, paragraph 4, of this Agreement.

ARTICLE III

For the purposes of this Agreement, the cessation of plutonium production specified in Article I, paragraph 2, will require the cessation of production by the reactors listed in Annex II to this Agreement of spent fuel containing plutonium whose combined Pu-240 plus Pu-238 isotopic concentration is less than 20 percent of total Pu, averaged over the total fuel discharged in any one batch. Once each reactor listed in Annex II to this Agreement is modified, it will utilize an alternative type of fuel including uranium derived from dismantled nuclear weapons.

ARTICLE IV

The plutonium produced after entry into force of this Agreement in the reactors identified in Annex II to this Agreement, and any high-enriched uranium recovered from spent fuel discharged from the modified reactors, shall not be used in nuclear weapons.

ARTICLE V

Procedures necessary to assure compliance with the obligations provided for in Articles I, III, and IV of this Agreement are contained in Annex III, which is an integral part of this Agreement.

ARTICLE VI

1. In order to prevent access to it by people and organizations not participating in the implementation of this Agreement, information transmitted under this Agreement may be considered as sensitive by the Parties. Such information must be clearly designated and marked. The Party transmitting the information shall designate information as sensitive in accordance with its internal laws and regulations.
2. The Party receiving the information shall handle this information as sensitive.
3. Sensitive information shall be handled in accordance with the laws and regulations of the Party receiving the information, and this information shall not be disclosed or transmitted to a third Party not participating in implementation of this Agreement without the clearly expressed consent of the Party transmitting the information. According to the regulations of the United States, such information shall be treated as foreign government information provided in confidence and shall be protected appropriately. According to the regulations of the Russian Federation, such information shall be treated as official information with limited distribution and shall be protected appropriately.
4. The Parties shall assure effective protection of and allocation of rights to intellectual property transmitted or created under this Agreement, as set forth in this Article and in Annex IV to this Agreement, which forms an integral part of this Agreement.

5. Information transmitted under this Agreement must be used solely for the purposes established by this Agreement in accordance with the laws, regulations, and mutual interests of the States represented by the Parties.
6. The number of people having access to sensitive information must be limited to the number .necessary to implement this Agreement and other programs associated with this Agreement.

ARTICLE VII

In order to ensure the possibility of taking the reactors listed in Annex II to this Agreement out of operation, the Russian Party shall undertake to create alternative sources of thermal and electrical energy to replace these reactors by the time of their final shutdown. To assist this effort, the U.S. Party will encourage private sector participation in the creation of replacement sources of energy. The U.S. Party does not guarantee the participation of the private sector in these activities, and its degree of success in this effort shall not alter in any way the obligations undertaken by the Parties in this Agreement.

ARTICLE VIII

The Parties shall designate Executive Agents to implement this Agreement and its Annexes and Subsidiary Arrangements as follows: for the U.S. Party, the Executive Agents shall be the Department of Defense for implementation of Article II and the Department of Energy for the implementation of the remainder of the Agreement and its Annexes and Subsidiary Arrangements; for the Russian Party, the Executive Agent shall be the Ministry of the Russian Federation for Atomic Energy. After consultation with the other Party, either Party shall have the right to change its Executive Agent upon 30 days' written notice to the other Party.

ARTICLE IX

To ensure achievement of the objectives and implementation of this Agreement, the Parties hereby establish a Joint Implementation and Compliance Commission (JICC), which shall convene no later than 21 days following the request of either Party, unless otherwise agreed. The tasks of the JICC shall include the following:

(a) To review implementation of this Agreement, to include resolution, by mutual agreement, of any implementation issues;
(b) To consider questions concerning implementation and effectiveness of monitoring procedures;
(c) To resolve any disputes that may arise regarding compliance with the provisions of this Agreement or its Annexes or Subsidiary Arrangements; and
(d) To discuss and, if necessary, prepare recommendations concerning any amendments to this Agreement or its Annexes or Subsidiary Arrangements, as well as proposals for resolving any disputes that cannot be resolved in the JICC.

ARTICLE X

In the event of conflict between the provisions of this Agreement and any Annexes or Subsidiary Arrangements to this Agreement, the provisions of this Agreement shall prevail.

ARTICLE XI

1. This Agreement shall enter into force upon signature on the same date as the implementing agreement specified in Article II, paragraph 1, of this Agreement.
2. This Agreement may be amended by agreement between the Parties. Any such amendment shall enter into force upon signature.
3. Each of the Subsidiary Arrangements shall be considered to be an integral part of their respective Annex to this Agreement under the condition, however, that they can be changed and added to by agreement between the sides represented by their Executive Agents as they are described according to Article VIII of this Agreement.
4. This Agreement may be terminated by either Party by sending written notice through diplomatic channels of its intent to terminate this Agreement, in which case this Agreement terminates after one year from the date of sending this notification. Termination of this Agreement shall not affect the following:
   a. All the provisions of Article VI shall continue in effect; and
   b. The obligations provided for in Article IV of this Agreement, and the associated compliance

procedures, shall continue in effect with respect to plutonium produced at the reactors listed in Annex II to this Agreement between entry into force of this Agreement and the date of its termination. The procedures specified in Annex III of this Agreement cease to be applicable to this plutonium when the plutonium is being used for needs that are not inconsistent with the objectives of this Agreement, as detailed in Annex III.

DONE at Moscow, in duplicate, this twenty-third day of September, 1997, in the English and Russian languages, both texts being equally authentic.

Agreement Between The United States of America and The Union of Soviet Socialist Republics on the Prevention of Nuclear War

Signed at Washington June 22, 1973
Entered into force June 22, 1973

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Guided by the objectives of strengthening world peace and international security, Conscious that nuclear war would have devastating consequences for mankind, Proceeding from the desire to bring about conditions in which the danger of an outbreak of nuclear war anywhere in the world would be reduced and ultimately eliminated,

Proceeding from their obligations under the Charter of the United Nations regarding the maintenance of peace, refraining from the threat or use of force, and the avoidance of war, and in conformity with the agreements to which either Party has subscribed,

Proceeding from the Basic Principles of Relations between the United States of America and the Union of Soviet Socialist Republics signed in Moscow on May 29, 1972,

Reaffirming that the development of relations between the United States of America and the Union of Soviet Socialist Republics is not directed against other countries and their interests,

Have agreed as follows:

ARTICLE I

The United States and the Soviet Union agree that an objective of their policies is to remove the danger of nuclear war and of the use of nuclear weapons.

Accordingly, the Parties agree that they will act in such a manner as to prevent the development of situations capable of causing a dangerous exacerbation of their relations, as to avoid military confrontations, and as to exclude the outbreak of

nuclear war between them and between either of the Parties and other countries.

ARTICLE II

The Parties agree, in accordance with Article I and to realize the objective stated in that Article, to proceed from the premise that each Party will refrain from the threat or use of force against the other Party, against the allies of the other Party and against other countries, in circumstances which may endanger international peace and security. The Parties agree that they will be guided by these considerations in the formulation of their foreign policies and in their actions in the field of international relations.

ARTICLE III

The Parties undertake to develop their relations with each other and with other countries in a way consistent with the purposes of this Agreement.

ARTICLE IV

If at any time relations between the Parties or between either Party and other countries appear to involve the risk of a nuclear conflict, or if relations between countries not parties to this Agreement appear to involve the risk of nuclear war between the United States of America and the Union of Soviet Socialist Republics or between either Party and other countries, the United States and the Soviet Union, acting in accordance with the provisions of this Agreement, shall immediately enter into urgent consultations with each other and make every effort to avert this risk.

ARTICLE V

Each Party shall be free to inform the Security Council of the United Nations, the Secretary General of the United Nations and the Governments of allied or other countries of the progress and outcome of consultations initiated in accordance with Article IV of this Agreement.

ARTICLE VI

Nothing in this Agreement shall affect or impair:

(a) the inherent right of individual or collective self-defense as envisaged by Article 51 of the Charter of the United Nations,*
(b) the provisions of the Charter of the United Nations, including those relating to the maintenance or restoration of international peace and security, and
(c) the obligations undertaken by either Party towards its allies or other countries in treaties, agreements, and other appropriate documents.

ARTICLE VII

This Agreement shall be of unlimited duration.

ARTICLE VIII

This Agreement shall enter into force upon signature.

DONE at Washington on June 22, 1973, in two copies, each in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES OF AMERICA:
RICHARD NIXON
President of the United States of America
FOR THE UNION OF SOVIET SOCIALIST REPUBLICS:
L.I. BREZHNEV
General Secretary of the Central Committee, CPSU

Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Seabed and the Ocean Floor and in the Subsoil Thereof

Signed at Washington, London, and Moscow February 11, 1971
Ratification advised by U.S. Senate February 15, 1972
Ratified by U.S. President April 26, 1972
Entered into force May 18, 1972

The States Parties to this Treaty,

Recognizing the common interest of mankind in the progress of the exploration and use of the seabed and the ocean floor for peaceful purposes,

Considering that the prevention of a nuclear arms race on the seabed and the ocean floor serves the interests of maintaining world peace, reduces international tensions and strengthens friendly relations among States,

Convinced that this Treaty constitutes a step towards the exclusion of the seabed, the ocean floor and the subsoil thereof from the arms race,

Convinced that this Treaty constitutes a step towards a Treaty on general and complete disarmament under strict and effective international control, and determined to continue negotiations to this end,

Convinced that this Treaty will further the purposes and principles of the Charter of the United Nations, in a manner consistent with the principles of international law and without infringing the freedoms of the high seas,

Have agreed as follows:

ARTICLE I

1. The States Parties to this Treaty undertake not to emplant or emplace on the seabed and the ocean floor and in the subsoil thereof beyond the outer limit of a seabed zone, as defined in article II, any nuclear weapons or any other types of weapons of mass destruction as well as structures, launching installations or any other facilities specifically designed for storing, testing or using such weapons.
2. The undertakings of paragraph 1 of this article shall also apply to the seabed zone referred to in the same paragraph, except that within such seabed zone, they shall not apply either to the coastal State or to the seabed beneath its territorial waters.
3. The States Parties to this Treaty undertake not to assist, encourage or induce any State to carry out activities referred to in paragraph 1 of this article and not to participate in any other way in such actions.

ARTICLE II

For the purpose of this Treaty, the outer limit of the seabed zone referred to in article I shall be coterminous with the twelve-mile outer limit of the zone referred to in part II of the Convention on the Territorial Sea and the

Contiguous Zone, signed at Geneva on April 29, 1958, and shall be measured in accordance with the provisions of part I, section II, of that Convention and in accordance with international law.

ARTICLE III

1. In order to promote the objectives of and insure compliance with the provisions of this Treaty, each State Party to the Treaty shall have the right to verify through observations the activities of other States Parties to the Treaty on the seabed and the ocean floor and in the subsoil thereof beyond the zone referred to in article I, provided that observation does not interfere with such activities.
2. If after such observation reasonable doubts remain concerning the fulfillment of the obligations assumed under the Treaty, the State Party having such doubts and the State Party that is responsible for the activities giving rise to the doubts shall consult with a view to removing the doubts. If the doubts persist, the State Party having such doubts shall notify the other States Parties, and the Parties concerned shall cooperate on such further procedures for verification as may be agreed, including appropriate inspection of objects, structures, installations or other facilities that reasonably may be expected to be of a kind described in article I. The Parties in the region of the activities, including any coastal State, and any other Party so requesting, shall be entitled to participate in such consultation and cooperation. After completion of the further procedures for verification, an appropriate report shall be circulated to other Parties by the Party that initiated such procedures.
3. If the State responsible for the activities giving rise to the reasonable doubts is not identifiable by observation of the object, structure, installation or other facility, the State Party having such doubts shall notify and make appropriate inquiries of States Parties in the region of the activities and of any other State Party. If it is ascertained through these inquiries that a particular State Party is responsible for the activities, that State Party shall consult and cooperate with other Parties as provided in paragraph 2 of this article. If the identity of the State responsible for the activities cannot be ascertained through these inquiries, then further verification procedures, including inspection, may be undertaken by the inquiring State Party, which shall invite the participation of the Parties in the region of the activities, including any coastal State, and of any other Party desiring to cooperate.
4. If consultation and cooperation pursuant to paragraphs 2 and 3 of this article have not removed the doubts concerning the activities and there remains a serious question concerning fulfillment of the obligations assumed under this Treaty, a State Party may, in accordance with the provisions of the Charter of the United Nations, refer the matter to the Security Council, which may take action in accordance with the Charter.
5. Verification pursuant to this article may be undertaken by any State Party using its own means, or with the full or partial assistance of any other State Party, or through appropriate international procedures within the framework of the United Nations and in accordance with its Charter.
6. Verification activities pursuant to this Treaty shall not interfere with activities of other States Parties and shall be conducted with due regard for rights recognized under international law, including the freedoms of the high seas and the rights of coastal States with respect to the exploration and exploitation of their continental shelves.

ARTICLE IV

Nothing in this Treaty shall be interpreted as supporting or prejudicing the position of any State Party with respect to existing international conventions, including the 1958 Convention on the Territorial Sea and the Contiguous Zone, or with respect to rights or claims which such State Party may assert, or with respect to recognition or non-recognition of rights or claims asserted by any other State, related to waters off its coasts, including, *inter alia,* territorial seas and contiguous zones, or to the seabed and the ocean floor, including continental shelves.

ARTICLE V

The Parties to this Treaty undertake to continue negotiations in good faith concerning further measures in the field of disarmament for the prevention of an arms race on the seabed, the ocean floor and the subsoil thereof.

ARTICLE VI

Any State Party may propose amendments to this Treaty. Amendments shall enter into force for each State Party accepting the amendments upon their acceptance by a majority of the States Parties to the Treaty and, thereafter, for each remaining State Party on the date of acceptance by it.

ARTICLE VII

Five years after the entry into force of this Treaty, a conference of Parties to the Treaty shall be held at Geneva, Switzerland, in order to review the operation of this Treaty with a view to assuring that the purposes of the preamble and the provisions of the Treaty are being realized. Such review shall take into account any relevant technological developments. The review conference shall determine, in accordance with the views of a majority of those Parties attending, whether and when an additional review conference shall be convened.

ARTICLE VIII

Each State Party to this Treaty shall in exercising its national sovereignty have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other States Parties to the Treaty and to the United Nations Security Council three months in advance. Such notice shall include a statement of the extraordinary events it considers to have jeopardized its supreme interests.

ARTICLE IX

The provisions of this Treaty shall in no way affect the obligations assumed by States Parties to the Treaty under international instruments establishing zones free from nuclear weapons.

ARTICLE X

1. This Treaty shall be open for signature to all States. Any State which does not sign the Treaty before its entry into force in accordance with paragraph 3 of this article may accede to it at any time.
2. This Treaty shall be subject to ratification by signatory States. Instruments of ratification and of accession shall be deposited with the Governments of the United States of America, the United Kingdom of Great Britain and Northern Ireland, and the Union of Soviet Socialist Republics, which are hereby designated the Depositary Governments.
3. This Treaty shall enter into force after the deposit of instruments of ratification by twenty-two Governments, including the Governments designated as Depositary Governments of this Treaty.
4. For states whose instruments of ratification or accession are deposited after the entry into force of this Treaty, it shall enter into force on the date of the deposit of their instruments of ratification or accession.
5. The Depositary Governments shall promptly inform the Governments of all signatory and acceding States of the date of each signature, of the date of deposit of each instrument of ratification or of accession, of the date of the entry into force of this Treaty, and of the receipt of other notices.
6. This Treaty shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations.

ARTICLE XI

This Treaty, the English, Russian, French, Spanish and Chinese texts of which are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of this Treaty shall be transmitted by the Depositary Governments to the Governments of the States signatory and acceding thereto.

IN WITNESS WHEREOF the undersigned, being duly authorized thereto, have signed this Treaty.

DONE in triplicate, at the cities of Washington, London and Moscow, this eleventh day of February, one thousand nine hundred seventy-one.

Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Reduction and Limitation of Strategic Offensive Arms (START I)

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Conscious that nuclear war would have devastating consequences for all humanity, that it cannot be won and must never be fought,

Convinced that the measures for the reduction and limitation of strategic offensive arms and the other obligations set forth in this Treaty will help to reduce the risk of outbreak of nuclear war and strengthen international peace and security,

Recognizing that the interests of the Parties and the interests of international security require the strengthening of strategic stability,

Mindful of their undertakings with regard to strategic offensive arms in Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons of July 1, 1968; Article XI of the Treaty on the Limitation of Anti-Ballistic Missile Systems of May 26, 1972; and the Washington Summit Joint Statement of June 1, 1990, [ABA]

Have agreed as follows:

ARTICLE I

Each Party shall reduce and limit its strategic offensive arms in accordance with the provisions of this Treaty, and shall carry out the other obligations set forth in this Treaty and its Annexes, Protocols, and Memorandum of Understanding.

ARTICLE II

1. Each Party shall reduce and limit its ICBMs and ICBM launchers, SLBMs and SLBM launchers, heavy bombers, ICBM warheads, SLBM warheads, and heavy bomber armaments, so that seven years after entry into force of this Treaty and thereafter, the aggregate numbers, as counted in accordance with Article III of this Treaty, do not exceed:

(a) 1600, for deployed ICBMs and their associated launchers, deployed SLBMs and their associated launchers, and deployed heavy bombers, including 154 for deployed heavy ICBMs and their associated launchers; [RF MOU, Section II] [US MOU, Section II] [Agreed State 33]

(b) 6000, for warheads attributed to deployed ICBMs, deployed SLBMs, and deployed heavy bombers, [RF MOU, Section II] [US MOU, Section II] including: [Agreed State 33] [START II, Art. I,3]

(i) 4900, for warheads attributed to deployed ICBMs and deployed SLBMs; [RF MOU, Section II] [US MOU, Section II] [START II, Art. I,4] [Agreed State 33]

(ii) 1100, for warheads attributed to deployed ICBMs on mobile launchers of ICBMs; [RF MOU, Section II]

(iii) 1540, for warheads attributed to deployed heavy ICBMs. [phased heavy reductions [RF MOU, Section II] ABA

2. Each Party shall implement the reductions pursuant to paragraph 1 of this Article in three phases, so that its strategic offensive arms do not exceed:

(a) by the end of the first phase, that is, no later than 36 months after entry into force of this Treaty, and thereafter, the following aggregate numbers:

(i) 2100, for deployed ICBMs and their associated launchers, deployed SLBMs and their associated launchers, and deployed heavy bombers;

(ii) 9150, for warheads attributed to deployed ICBMs, deployed SLBMs, and deployed heavy bombers;

(iii)b 8050, warheads attributed to deployed ICBMs and deployed SLBMs;

(b) by the end of the second phase, that is, no later than 60 months after entry into force of this Treaty, and thereafter, the following aggregate numbers:

(i) 1900, for deployed ICBMs and their associated launchers, deployed SLBMs and their associated launchers, and deployed heavy bombers;

(ii) 7950, for warheads attributed to deployed ICBMs, deployed SLBMs, and deployed heavy bombers;

(iii) 6750, warheads attributed to deployed ICBMs and deployed SLBMs;

(c) by the end of the third phase, that is, no later than 84 months after entry into force of this Treaty: the aggregate numbers provided for in paragraph 1 of this Article .ABA

3. Each Party shall limit the aggregate throw-weight [RF MOU, Section II] [US MOU Section II] of its deployed ICBMs [RF MOU, Section I] [US MOU Section I] and deployed SLBMs [RF MOU, Section I] [US MOU Section I] so that seven years after entry into force of this Treaty and thereafter such aggregate throw-weight does not exceed 3600 metric tons. ABA [Throw-weight Limits/Provisions for Types of ICBMs and SLBMs]

ARTICLE III

1. For the purposes of counting toward the maximum aggregate limits provided for in subparagraphs 1(a), 2(a)(i), and 2(b)(i) of Article II of this Treaty:

(a) Each deployed ICBM and its associated launcher shall be counted as one unit; each deployed SLBM and its associated launcher; shall be counted as one unit.

(b) Each deployed heavy bombers shall be counted as one unit. ABA

2. For the purposes of counting deployed ICBMs and their associated launchers and deployed SLBMs and their associated launchers

(a) Each deployed launcher of ICBMs and each deployed launcher of SLBMs shall be considered to contain one deployed ICBM or one deployed SLBM, respectively. ABA

(b) If a deployed ICBM has been removed from its launcher and another missile has not been installed in that launcher, such an ICBM removed from its launcher and located at that ICBM base shall continue to be considered to be contained in that launcher. ABA

(c) If a deployed SLBM has been removed from its launcher and another missile has not been installed in that launcher, such an SLBM removed from its launcher shall be considered to be contained in that launcher. Such an SLBM removed from its launcher shall be located only at a facility at which non-deployed SLBMs may be located pursuant to subparagraph 9(a) of Article IV of this Treaty or be in movement to such a facility. ABA

3. For the purposes of this Treaty, including counting ICBMs and SLBMs:

(a) For ICBMs or SLBMs that are maintained, stored, and transported in stages, the first stage of an ICBM or SLBM of a particular type shall be considered to be an ICBM or SLBM of that type. [US MOU Annex F] [RF MOU, Annex F]

(b) For ICBMs or SLBMs that are maintained, stored, and transported as assembled missiles without launch canisters, an assembled missile of a particular type shall be considered to be an ICBM or SLBM of that type. [RF MOU, Annex F]

(c) For ICBMs that are maintained, stored, and transported as assembled missiles in launch canisters, an assembled missile of a particular type, in its launch canister, shall be considered to be an ICBM of that type. [RF MOU, Annex F]

(d) Each launch canister shall be considered to contain an ICBM from the time it first leaves a facility at which an ICBM is installed in it until an ICBM has been launched from it or until an ICBM has been removed from it for elimination. A launch canisters shall not be considered to contain an ICBM if it contains a training model of a missile or has been placed on static display. Launch canisters for ICBMs of a particular type shall be distinguishable from launch canisters for ICBMs of a different type.

4. For the purposes of counting warheads:

(a) The number of warheads attributed to an ICBM or SLBM of each existing type shall be the number specified in the Memorandum of Understanding [RF MOU, Section I] [US MOU, Section I] on the Establishment of the Data Base Relating to this Treaty, hereinafter referred to as the Memorandum of Understanding.

(b) The number of warheads that will be attributed to an ICBM or SLBM of a new type shall be the maximum number of reentry vehicles with which an ICBM or SLBM of that type has been flight-tested. The number of warheads that will be attributed to an ICBM or SLBM of a new type with a front section of an existing design with multiple reentry vehicles, or to an ICBM or SLBM of a new type with one reentry vehicle, shall be no less than the nearest integer that is smaller than the result of dividing 40 percent of the accountable throw-weight of the ICBM or SLBM by the weight of the lightest reentry vehicle flight-tested on an ICBM of SLBM of a new type. In the case of an ICBM or SLBM of a new type with a of warheads that will be attributed to an ICBM of SLBM of a new type with a front section of a fundamentally new design, the question of the applicability of the 40-percent rule to such an ICBM or SLBM shall be subject to agreement within the framework of the Joint Compliance and Inspection Commission. Until agreement has been reached regarding the rule that will apply to such an ICBM or SLBM, the number of warheads that will be attributed to such an ICBM or SLBM shall be the maximum number of reentry vehicles with which an ICBM or SLBM of that type has been flight-tested. The number of new types of ICBMs or SLBMs with a front section of a fundamentally new design shall not exceed two for each Party as long as this Treaty remains in force. [Agreed State 24]

(c) The number of reentry vehicles with which an ICBM or SLBM has been flight-tested shall be considered to be the sum of the number of reentry vehicles actually released during the flight test, plus the number of procedures for dispensing reentry vehicles performed during that same flight test when no reentry vehicle was released. A procedure for dispensing penetration aids shall not be considered to be a procedure for dispensing reentry vehicles, provided that the procedure for dispensing penetration aids differs from a procedure for dispensing reentry vehicles.

(d) Each reentry vehicle of an ICBM or SLBM shall be considered to be one warhead. [Agreed State 3]

(e) For the United States of America, each heavy bomber equipped for long-range nuclear ALCMs, up to a total of 150 such heavy bombers, shall be attributed [MOU US Section I] with ten warheads. Each heavy bomber equipped for long-range nuclear ALCMs in excess of 150 such heavy bombers shall be attributed [MOU US Section I] with a number of warheads equal to the number of long-range nuclear ALCMs for which it is actually equipped. The United States of America shall specify the heavy bombers equipped for long-range nuclear ALCMs that are in excess of 150 such heavy bombers by number, type, variant, and the air bases at which they are based. The number of long-range nuclear ALCMs for which each heavy bomber equipped for long-range nuclear ALCMs in excess of 150 such heavy bombers is considered to be actually equipped shall be the maximum number of long-range nuclear ALCMs for which a heavy bomber of the same type and variant is actually equipped. [category]

(f) For the Union of Soviet Socialist Republics, each heavy bomber equipped for long-range nuclear ALCMs, up to a total of 180 such heavy bombers, shall be attributed [MOU RF Section I] with eight warheads. Each heavy bomber equipped for long-range nuclear ALCMs in excess of 180 such heavy bombers shall be attributed with a number of warheads equal to the number of long-range nuclear ALCMs for which it is actually equipped. The Union of Soviet Socialist Republics shall specify the heavy bombers equipped for long-range nuclear ALCMs that are in excess of 180 such heavy bombers by number, type, variant, and the air bases at which they are based. The number of long-range nuclear ALCMs for which each heavy bomber equipped for long-range nuclear ALCMs in excess of 180 such heavy bombers is considered to be actually equipped shall be the maximum number of long-range nuclear ALCMs for which a heavy bomber of the same type and variant is actually equipped. [category]

(g) Each heavy bomber equipped for nuclear armaments other than long-range nuclear ALCMs [MOU US Annex G] [MOU RF Annex G] shall be attributed [MOU US Section I] [MOU RF Section I] with one warhead. All heavy bombers not equipped for long-range nuclear ALCMs shall be considered to be heavy bombers equipped for nuclear armaments other than long-range nuclear ALCMs, with the exception of heavy bombers equipped for non-nuclear armaments, test heavy bombers, and training heavy bombers. [category] [START II, Art. IV.1,2]

5. Each Party shall have the right to reduce the number of warheads attributed to ICBMs and SLBMs only of existing types, up to an aggregate number of 1250 at any one time. [START MOU, Section III] [MOU RF Section III] [START II Art III. 2 (a)]

(a) Such aggregate number shall consist of the following:

(i)b for the United States of America, the reduction in the number of warheads attributed to the type of ICBM designated by the United States of America as, and known to the Union of Soviet Socialist Republics as, Minuteman III, plus the reduction in the number of warheads attributed to ICBMs and SLBMs of no more than two other existing types; [START MOU, Section III]

(ii) b for the Union of Soviet Socialist Republics, four multiplied by the number of deployed SLBMs designated by the Union of Soviet Socialist Republics as RSM-50, which is known to the United States of America as SS-N-18, [MOU RF Section III] plus the reduction in the number of warheads attributed to ICBMs and SLBMs of no more than two other existing types.

(b) Reductions in the number of warheads attributed to Minuteman III shall be carried out subject to the following:

(i) Minuteman III to which different numbers of warheads are attributed shall not be deployed at the same ICBM base.

(ii) Any such reductions shall be carried out no later than seven years after entry into force of this Treaty.

(iii) The reentry vehicle platform of each Minuteman III to which a reduced number of warheads is attributed shall be destroyed and replaced by a new reentry vehicle platform. [START II Art III.2(d)]

(c) Reductions in the number of warheads attributed to ICBMs and SLBMs of types other than Minuteman III shall be carried out subject to the following:

(i)b Such reductions shall not exceed 500 warheads at any one time for each Party. [START II Art III.2(b)]

(ii) After a Party has reduced the number of warheads attributed to ICBMs or SLBMs of two existing types, that Party shall not have the right to reduce the number of warheads attributed to ICBMs or SLBMs of any additional type.

(iii) The number of warheads attributed to an ICBM or SLBM shall be reduced by no more than four below the number attributed as of the date of signature of this Treaty. [START II Art III.2(c)]

(iv) ICBMs of the same type, but to which different numbers of warheads are attributed, shall not be deployed at the same ICBM base.

(v) SLBMs of the same type, but to which different numbers of warheads are attributed, shall not be deployed on submarines based at submarine bases adjacent to the waters of the same ocean.

(vi) If the number of warheads attributed to an ICBM or SLBM of a particular type is reduced by more than two, the reentry vehicle platform of each ICBM or SLBM to which such a reduced number of warheads is attributed shall be destroyed and replaced by a new reentry vehicle platform. [START II Art III.2(d)]

(d) A Party shall not have the right to attribute to ICBMs of a new type a number of warheads greater than the smallest number of warheads attributed to any ICBM to which that Party has attributed a reduced number of warheads pursuant to subparagraph (c) of this paragraph. A Party shall not have the right to attribute to

SLBMs of a new type a number of warheads greater than the smallest number of warheads attributed to any SLBM to which that Party has attributed a reduced number of warheads pursuant to subparagraph (c) of this paragraph.

6. Newly constructed strategic offensive arms shall begin to be subject to the limitations provided for in this Treaty as follows:

(a) an ICBM, when it first leaves a production facility;

(b) a mobile launcher of ICBMs, when it first leaves a production facility for mobile launchers of ICBMs;

(c) a silo launcher of ICBMs, when excavation for that launcher has been completed and the pouring of concrete for the silo has been completed, or 12 months after the excavation begins, whichever occurs earlier;

(d) for the purpose of counting a deployed ICBM and its associated launcher, a silo launchers of ICBMs shall be considered to contain a deployed ICBM when excavation for that launcher has been completed and the pouring of concrete for the silo has been completed, or 12 months after the excavation begins, whichever occurs earlier, and a mobile launcher of ICBMs shall be considered to contain a deployed ICBM when it arrives at a maintenance facility, [Def 19] except for the non-deployed mobile launchers of ICBMs provided for in subparagraph 2(b) of Article IV of this Treaty, or when it leaves an ICBM loading facility;

(e) an SLBM, when it first leaves a production facility;

(f) an SLBM launcher, when the submarine on which that launcher is installed is first launched;

(g) for the purpose of counting a deployed SLBM and its associated launcher, an SLBM launcher shall be considered to contain a deployed SLBM when the submarine on which that launcher is installed is first launched; [Def 18]

(h) a heavy bomber or former heavy bomber, when its airframe is first brought out of the shop, plant, or building in which components of a heavy bomber or former heavy bomber are assembled to produce complete airframes; or when its airframe is first brought out of the shop, plant, or building in which existing bomber airframes are converted to heavy bomber or former heavy bomber airframes. [Def 14] [Def 82 (d)] [Agreed State 12]

7. ICBM launchers and SLBM launchers that have been converted to launch an ICBM or SLBM, respectively, of a different type shall not be capable of launching an ICBM or SLBM of the previous type. Such converted launchers shall be considered to be launchers of ICBMs or SLBMs of that different type as follows:

(a) a silo launchers of ICBMs, when an ICBM of a different type or a training model of a missile of a different type is first installed in that launcher, or when the silo door is reinstalled, whichever occurs first; [Notocol IV.3]

(b) a mobile launcher of ICBMs, as agreed within the framework of the Joint Compliance and Inspection Commission;

(c) an SLBM launcher, when all launchers on the submarine on which that launcher is installed have been converted to launch an SLBM of that different type and that submarine begins sea trials, that is, when that submarine first operates under its own power away from the harbor or port in which the conversion of launchers was performed. [Notocol V.4]

8. Heavy bombers that have been converted into heavy bombers of a different category or into former heavy bombers shall be considered to be heavy bombers of that different category or former heavy bombers as follows:

(a) a heavy bomber equipped for nuclear armaments other than long-range nuclear ALCMs converted into a heavy bomber equipped for long-range nuclear ALCMs, when it is first brought out of the shop, plant, or building where it was equipped for long-range nuclear ALCMs; [US MOU Annex G, (I), (II), (III) [RF MOU Annex G, (i), (ii)]

(b) a heavy bomber of one category converted into a heavy bomber of another category provided for in paragraph 9 of Section VI of the Protocol on Procedures Governing the Conversion or Elimination of the Items Subject to this Treaty, hereinafter referred to as the Conversion or Elimination Protocol, or into a former heavy bomber, when the inspection conducted pursuant to paragraph 13 of Section VI of the Conversion or Elimination Protocol is completed or, if such an inspection is not conducted, when the 20-day period provided for in paragraph 13 of Section VI of the Conversion or Elimination Protocol expires.

9. For the purposes of this Treaty:

(a) A ballistic missile of a type developed and tested solely to intercept and counter objects not located on the surface of the Earth shall not be considered to be a ballistic missile to which the limitations provided for in this Treaty apply.

(b) If a ballistic missile has been flight-tested or deployed for weapon delivery, all ballistic missiles of that type shall be considered to be weapon-delivery vehicles.

(c) If a cruise missile has been flight-tested or deployed for weapon delivery, all cruise missiles of that type shall be considered to be weapon-delivery vehicles.

(d) If a launcher, other than a soft-site launcher, has contained an ICBM or SLBM of a particular type, it shall be considered to be a launcher of ICBMs or SLBMs of that type. If a launcher, other than a soft-site launcher, has been converted into a launcher of ICBMs or SLBMs of a different type, it shall be considered to be a launcher of ICBMs or SLBMs of the type for which it has been converted.

(e) If a heavy bomber is equipped for long-range nuclear ALCMs, all heavy bombers of that type shall be considered to be equipped for long-range nuclear ALCMs, except those that are not so equipped and are distinguishable from heavy bombers of the same type equipped for long-range nuclear ALCMs. If long-range nuclear ALCMs have not been flight-tested from any heavy bomber of a particular type, no heavy bomber of that type shall be considered to be equipped for long-range nuclear ALCMs. Within the same type, a heavy bomber equipped for long-range nuclear ALCMs, a heavy bomber equipped for nuclear armaments other than long-range nuclear ALCMs, a heavy bomber equipped for non-nuclear armaments, a training heavy bomber, and a former heavy bomber shall be distinguishable from one another. [category] [US MOU Annex G, (I), (II), (III)] [RF MOU Annex G, (i), (ii)]

(f) Any long-range ALCM of a type, any one of which has been initially flight-tested from a heavy bomber on or before December 31, 1988, shall be considered to be a long-range nuclear ALCM. Any long-range ALCM of a type, any one of which has been initially flight-tested from a heavy bomber after December 31, 1988, shall not be considered to be a long-range nuclear ALCM if it is a long-range non-nuclear ALCM and is distinguishable from long-range nuclear ALCMs. Long-range non-nuclear ALCMs not so distinguishable shall be considered to be long-range nuclear ALCMs. [TACIT RAINBOW] [TSSAM Statements]

(g) Mobile launchers of ICBMs of each new type of ICBM shall be distinguishable from mobile launchers of ICBMs of existing types of ICBMs and from mobile launchers of ICBMs of other new type of ICBMs. Such new launchers, with their associated missiles installed, shall be distinguishable from mobile launchers of ICBMs of existing types of ICBMs with their associated missiles installed, and from mobile launchers of ICBMs of other new types of ICBMs with their associated missiles installed. [RF MOU Annex F] [US MOU Annex F] [Agreed State 19]

(h) Mobile launchers of ICBMs converted into launchers of ICBMs of another type of ICBM shall be distinguishable from mobile launchers of ICBMs of the previous type of ICBM. Such converted launchers, with their associated missiles installed, shall be distinguishable from mobile launchers of ICBMs of the previous type of ICBM with their associated missiles installed. Conversion of mobile launchers of ICBMs shall be carried out in accordance with procedures to be agreed within the framework of the Joint Compliance and Inspection Commission. [Agreed State 19]

10. As of the date of signature of this Treaty:

(a) Existing types of ICBMs and SLBMs are:

(i)b for the United States of America, the types of missiles designated by the United States of America as Minuteman II, Minuteman III, Peacekeeper, Poseidon, Trident I, and Trident II, which are known to the Union of Soviet Socialist Republics as Minuteman II, Minuteman III, MX, Poseidon, Trident I, and Trident II, respectively; [US MOU Section I] [US MOU Annex F]

(ii) b for the Union of Soviet Socialist Republics, the types of missiles designated by the Union of Soviet Socialist Republics as RS-10, RS-12, RS-16, RS-20, RS-18, RS-22, RS-12M, RSM-25, RSM-40, RSM-50, RSM-52, and RSM-54, which are known to the United States of America as SS-11, SS-13, SS-17, SS-18, SS-19, SS-24, SS-25, SS-N-6, SS-N-8, SS-N-18, SS-N-20, and SS-N-23, respectively. [RF MOU Section I] [RF MOU, Annex F] [RF MOU Annex I]

(b) Existing types of ICBMs for mobile launchers of ICBMs are:

(i) for the United States of America, the type of missile designated by the United States of America as Peacekeeper, which is known to the Union of Soviet Socialist Republics as MX; [US MOU Annex F]

(ii) for the Union of Soviet Socialist Republics, the types of missiles designated by the Union of Soviet Socialist Republics as RS-22 and RS-12M, which are known to the United States of America as SS-24 and SS-25, respectively. [RF MOU, Annex F]

(c) Former types of ICBMs and SLBMs are the types of missiles designated by the United States of America as, and known to the Union of Soviet Socialist Republics as, Minuteman I and Polaris A-3.

(d) Existing types of heavy bombers are:

(i) for the United States of America, the types of bombers designated by the United States of America as, and known to the Union of Soviet Socialist Republics as, B-52, B-1, and B-2; [US MOU Annex G]

(ii) for the Union of Soviet Socialist Republics, the types of bombers designated by the Union of Soviet Socialist Republics as Tu-95 and Tu-160, which are known to the United States of America as Bear and Blackjack, respectively. [RF MOU, Annex G] [Soviet TU-22M Declaration]

(e) Existing types of long-range nuclear ALCMs are:

(i) for the United States of America, the types of long-range nuclear ALCMs designated by the United States of America as, and known to the Union of Soviet Socialist Republics as, AGM-86B and AGM-129; [US MOU Annex H]

(ii) for the Union of Soviet Socialist Republics, the types of long-range nuclear ALCMs designated by the Union of Soviet Socialist Republics as RKV-500A and RKV-500B, which are known to the United States of America as AS-15 A and AS-15 B, respectively. [RF MOU, Annex H]

[Nuclear SLCM Policy Declarations]

ARTICLE IV

1. For ICBMs and SLBMs:

(a) Each Party shall limit the aggregate number of non-deployed ICBMs for mobile launchers of ICBMs to no more than 250. Within this limit, the number of non-deployed ICBMs for rail-mobile launchers of ICBMs shall not exceed 125. [RF MOU, Section IV] [US MOU Section IV] [Agreed State 37]

(b) Each Party shall limit the number of non-deployed ICBMs at a maintenance facility of an ICBM base for mobile launchers of ICBMs to no more than two ICBMs of each type specified for that ICBM base. Non-deployed ICBMs for mobile launchers of ICBMs located at a maintenance facilityshall be stored separately from non-deployed mobile launchers of ICBMs located at that maintenance facility.

(c) Each Party shall limit the number of non-deployed ICBMs and sets of ICBM emplacement equipment at an ICBM base for silo launchers of ICBMs to no more than:

(i) two ICBMs of each type specified for that ICBM base and six sets of ICBM emplacement equipment for each type of ICBM specified for that ICBM base; or [RF MOU Annex A] [US MOU, Annex A]

(ii) four ICBMs of each type specified for that ICBM base and two sets of ICBM emplacement equipment for each type of ICBM specified for that ICBM base. [RF MOU Annex A] [US MOU, Annex A]

(d) Each Party shall limit the aggregate number of ICBMs and SLBMs located at test ranges to no more than 35 during the seven-year period after entry into force of this Treaty. Thereafter, the aggregate number of ICBMs and SLBMs located at test ranges shall not exceed 25. [RF MOU, Section IV] [US MOU Section IV] [Agreed State 37]

2. For ICBM launchers and SLBM launchers:

(a) Each Party shall limit the aggregate number of non-deployed mobile launchers of ICBMs to no more than 110. Within this limit, the number of non-deployed rail-mobile launchers of ICBMs shall not exceed 18. [RF MOU, Section IV] [US MOU Section IV]

(b) Each Party shall limit the number of non-deployed mobile launchers of ICBMs located at the maintenance facility of each ICBM base for mobile launchers of ICBMs to no more than two such ICBM launchers of each type of ICBM specified for that ICBM base. [RF MOU Annex A]

(c) Each Party shall limit the number of non-deployed mobile launchers of ICBMs located at training facilities for ICBMs to no more than 40. Each such launcher may contain only a training model of a missile. Non-deployed mobile launchers of ICBMs that contain training models of missiles shall not be located outside a training facility. [RF MOU, Section IV] [US MOU Section IV]

(d) Each Party shall limit the aggregate number of test launchers to no more than 45 during the seven-year period after entry into force of this Treaty. Within this limit, the number of fixed test launchers shall not exceed 25, and the number of mobile test launchers shall not exceed 20. Thereafter, the aggregate number of test launchers shall not exceed 40. Within this limit, the number of fixed test launchers shall not exceed 20, and the number of mobile test launchers shall not exceed 20. [RF MOU, Section IV] [US MOU Section IV] [Agreed State 37(h)]

(e) Each Party shall limit the aggregate number of silo training launchers and mobile training launchers to no more than 60. ICBMs shall not be launched from training launchers. Each such launcher may contain only a training model of a missile. Mobile training launchers shall not be capable of launching ICBMs, and shall differ from mobile launchers of ICBMs and other road vehicles or railcars on the basis of differences that are observable by national technical means of verification. [Agreed State 13] [RF MOU, Section IV] [US MOU Section IV]

3. For heavy bombers and former heavy bombers:

(a) Each Party shall limit the aggregate number of heavy bombers equipped for non-nuclear armaments, former heavy bombers, and training heavy bombers to no more than 75. [category] [RF MOU, Section IV] [US MOU Section IV] [Agreed State 6] [Agreed State 12]

(b) Each Party shall limit the number of test heavy bombers to no more than 20. [category] [RF MOU, Section IV] [US MOU Section IV]

4. For ICBMs and SLBMs used for delivering objects into the upper atmosphere or space: [JCIC Joint State 21]

(a) Each Party shall limit the number of space launch facilities to no more than five, unless otherwise agreed. Space launch facilities shall not overlap ICBM bases. [RF MOU, Annex D] [US MOU Annex D]

(b)Each Party shall limit the aggregate number of ICBM launchers and SLBM launchers located at space launch facilities to no more than 20, unless otherwise agreed. Within this limit, the aggregate number of silo launchers of ICBMs and mobile launchers of ICBMs located at space launch facilities shall not exceed ten, unless otherwise agreed. [Agreed State 26] [Agreed State 37(h)]

(c) Each Party shall limit the aggregate number of ICBMs and SLBMs located at a space launch facility to no more than the number of ICBM launchers and SLBM launchers located at that facility. [Agreed State 37]

5. Each Party shall limit the number of transporter-loaders for ICBMs for road-mobile launchers of ICBMs

located at each deployment area or test range to no more than two for each type of ICBM for road-mobile launchers of ICBMs that is attributed with one warhead and that is specified for that deployment area or test range, and shall limit the number of such transporter-loaders located outside deployment areas and test ranges to no more than six. The aggregate number of transporter-loaders for ICBMs for road-mobile launchers of ICBMs shall not exceed 30. [RF MOU, Section IV]

6. Each Party shall limit the number of ballistic missile submarines in dry dock within five kilometers of the boundary of each submarine base to no more than two.

7. For static displays and ground trainers:

(a) Each Party shall limit the number of ICBM launchers and SLBM launchers placed on static displays after signature of this Treaty to no more than 20, the number of ICBMs [RF MOU, Annex A] [US MOU, Annex A] [Uk MOU, Annex A] and SLBMs [RF MOU, Annex B] [US MOU, Annex B] placed on static display after signature of this Treaty to no more than 20, the number of launch canisters placed on static display after signature of this Treaty to no more than 20, and the number of heavy bombers and former heavy bombers placed on static display after signature of this Treaty to no more than 20. Such items placed on static display prior to signature of this Treaty shall be specified in Annex I to the Memorandum of Understanding, but shall not be subject to the limitations provided for in this Treaty.

(b) Each Party shall limit the aggregate number of heavy bombers converted after signature of this Treaty for use as ground trainers and former heavy bombers converted after signature of this Treaty for use as ground trainers to no more than five. Such items converted prior to signature of this Treaty for use as ground trainers shall be specified in Annex I to the Memorandum of Understanding, but shall not be subject to the limitations provided for in this Treaty.

8. Each Party shall limit the aggregate number of storage facilities for ICBMs or SLBMs and repair facilities for ICBMs or SLBMs to no more than 50.

9. With respect to locational and related restrictions on strategic offensive arms:

(a) Each Party shall locate non-deployed ICBMs and non-deployed SLBMs only at maintenance facilities of ICBM bases; submarine bases; ICBM loading facilities; SLBM loading facilities; production facilities for ICBMs or SLBMs; repair facilities for ICBMs or SLBMs; storage facilities for ICBMs or SLBMs; conversion or elimination facilities for ICBMs or SLBMs; test ranges; or space launch facilities. Prototype ICBMs and prototype SLBMs, however, shall not be located at maintenance facilities of ICBM bases or at submarine bases. Non-deployed ICBMs and non-deployed SLBMs may also be in transit. Non-deployed ICBMs for silo launchers of ICBMs may also be transferred within an ICBM base for silo launchers of ICBMs. Non-deployed SLBMs that are located on missile tenders and storage cranes shall be considered to be located at the submarine base at which such missile tenders and storage cranes are specified as based. [Agreed State 37] [Agreed State 19]

(b) Each Party shall locate non-deployed mobile launchers of ICBMs only at maintenance facilities of ICBM bases for mobile launchers of ICBMs, production facilities for mobile launchers of ICBMs, repair facilities for mobile launchers of ICBMs, storage facilities for mobile launchers of ICBMs, ICBM loading facilities, training facilities for ICBMs, conversion or elimination facilities for mobile launchers of ICBMs, test ranges, or space launch facilities. Mobile launchers of prototype ICBMs, however, shall not be located at maintenance facilities of ICBM bases for mobile launchers of ICBMs. Non-deployed mobile launchers of ICBMs may also be in transit. [Agreed State 19]

(c) Each Party shall locate test launchers only at test ranges, except that rail-mobile test launchers may conduct movements for the purpose of testing outside a test range, provided that:

(i) each such movement is completed no later than 30 days after it begins;

(ii) each such movement begins and ends at the same test ranges and does not involve movement to any other facility;

(iii) movements of no more than six rail-mobile launchers of ICBMs are conducted in each calendar year; and

(iv) no more than one train containing no more than three rail-mobile test launchers is located outside test ranges at any one time.

(d) A deployed mobile launcher of ICBMs and its associated missile that relocates to a test range may, at the discretion of the testing Party, either continue to be counted toward the maximum aggregate limits provided for in Article II of this Treaty, or be counted as a mobile test launchers pursuant to paragraph 2(d) of this Article. If a deployed mobile launcher of ICBMs and its associated missile that relocates to a test range continues to be counted toward the maximum aggregate limits provided for in Article II of this Treaty, the period of time during which it continuously remains at a test range shall not exceed 45 days. The number of such deployed road-mobile launchers of ICBMs and their associated missiles located at a test range at any one time shall not exceed three, and the number of such deployed rail-mobile launchers of ICBMs and their associated missiles located at a test range at any one time shall not exceed three.

(e) Each Party shall locate silo training launchers only at ICBM bases for silo launchers of ICBMs and training facilities for ICBMs. The number of silo training launchers located at each ICBM bases for silo launchers of ICBMs shall not exceed one for each type of ICBM specified for that ICBM base.

(f) Test heavy bombersshall be based only at heavy bomber flight test centers and at production facilities for heavy bombers. Training heavy bombers shall be based only at training facilities for heavy bombers.

10. Each Party shall locate solid rocket motors for first stages of ICBMs for mobile launchers of ICBMs only at locations where production and storage, or testing of such motors occurs and at production facilities for ICBMs for mobile launchers of ICBMs. Such solid rocket motors may also be moved between these locations. Solid rocket motors with nozzles attached for the first stages of ICBMs for mobile launchers of ICBMs shall only be located at production facilities for ICBMs for mobile launchers of ICBMs and at locations where testing of such solid rocket motors occurs. Locations where such solid rocket motors are permitted shall be specified in Annex I to the Memorandum of Understanding. [RF MOU, Annex I] [US MOU, Annex I] [Agreed State 28]

11. With respect to locational restrictions on facilities:

(a) Each Party shall locate production facilities for ICBMs of a particular type, repair facilities for ICBMs of a particular type, storage facilities for ICBMs of a particular type, ICBM loading facilities for ICBMs of a particular type, and conversion or elimination facilities for ICBMs of a particular type no less than 100 kilometers from any ICBM base for silo launchers of ICBMs of that type of ICBM, any ICBM base for rail-mobile launchers of ICBMs of that type of ICBM, any deployment area for road-mobile launchers of ICBMs of that type of ICBM, any test range from which ICBMs of that type are flight-tested, any production facility for mobile launchers of ICBMs of that type of ICBM, any repair facility for mobile launchers of ICBMs of that type of ICBM, any storage facility for mobile launchers of ICBMs of that type of ICBM, and any training facility for ICBMs at which non-deployed mobile launchers of ICBMs are located. New facilities at which non-deployed ICBMs for silo launchers of ICBMs of ICBMs of any type of ICBM may be located, and new storage facilities for ICBM emplacement equipment, shall be located no less than 100 kilometers from any ICBM base for silo launchers of ICBMs, except that existing storage facilities for intermediate-range missiles, located less than 100 kilometers from an ICBM base for silo launchers of ICBMs or from a test range, may be converted into storage facilities for ICBMs not specified for that ICBM base or that test range. [Agreed State 14]

(b) Each Party shall locate production facilities for mobile launchers of ICBMs of a particular type of ICBM, repair facilities for mobile launchers of ICBMs of a particular type of ICBM, and storage facilities for mobile launchers of ICBMs of a particular type of ICBM no less than 100 kilometers from any ICBMs for mobile launchers of ICBMs of that type of ICBM and any test range from which ICBMs of that type are flight-tested.

(c) Each Party shall locate test ranges and space launch facilities no less than 100 kilometers from any ICBM base for silo launchers of ICBMs, any ICBM base for rail-mobile launchers of ICBMs, and any deployment area. [Agreed State 26]

(d) Each Party shall locate training facilities for ICBMs no less than 100 kilometers from any test range. [Agreed State 15]

(e) Each Party shall locate storage areas for heavy bomber nuclear armaments no less than 100 kilometers from any air base for heavy bombers equipped for non-nuclear armaments and any training facility for heavy bombers. Each Party shall locate storage areas for long-range nuclear ALCMs no less than 100 kilometers from any air base for heavy bombers equipped for nuclear armaments other than long-range nuclear ALCMs, any air base for heavy bombers equipped for non-nuclear armaments, and any training facility for heavy bombers.

12. Each Party shall limit the duration of each transit to no more than 30 days.

ARTICLE V

1. Except as prohibited by the provisions of this Treaty, modernization and replacement of strategic offensive arms may be carried out.

2. Each Party undertakes not to:

(a) produce, flight-test, or deploy heavy ICBMs of a new type, or increase the launch weight [RF MOU, Annex F] or throw-weight [RF MOU, Section I] of heavy ICBMs of an existing type;

(b) produce, flight-test, or deploy heavy SLBMs;

(c) produce test, or deploy mobile launchers of heavy ICBMs;

(d) produce, test, or deploy additional silo launchers of ICBMs of heavy ICBMs, except for silo launchers of heavy ICBMs that replace silo launchers of heavy ICBMs that have been eliminated in accordance with Section II of the Conversion or Elimination Protocol, provided that the limits provided for in Article II of this Treaty are not exceeded; [Agreed State 5]

(e) convert launchers that are not launchers of heavy ICBMs into launchers of heavy ICBMs;

(f) produce, test, or deploy launchers of heavy SLBMs;

(g) reduce the number of warheads attributed to a heavy ICBM of an existing type.

3. Each Party undertakes not to deploy ICBMs other than in silo launchers of ICBMs, on road-mobile launchers of ICBMs, or on rail-mobile launchers of ICBMs.

Each Party undertakes not to produce, test, or deploy ICBM launchers other than silo launchers of ICBMs, road-mobile launchers of ICBMs, or rail-mobile launchers of ICBMs.

4. Each Party undertakes not to deploy on a mobile launcher of ICBMs an ICBM of a type that was not specified as a type of ICBM for mobile launchers of ICBMs in accordance with paragraph 2 of Section VII of the Protocol on Notifications Relating to this Treaty, hereinafter referred to as the Notification Protocol, unless it is an ICBM to which no more than one warhead is attributed and the Parties have agreed within the framework of the Joint Compliance and Inspection Commission to permit deployment of such ICBMs on mobile launchers of ICBMs. A new type of ICBM for mobile launchers of ICBMs may cease to be considered to be a type of ICBM for mobile launchers of ICBMs if no ICBM of that type has been contained on, or flight-tested from, a mobile launcher of ICBMs.

5. Each Party undertakes not to deploy ICBM launchers of a new type of ICBM and not to deploy SLBM launchers of a new type of SLBM if such launchers are capable of launching ICBMs or SLBMs, respectively, of other types. ICBM launchers of existing types of ICBMs and SLBM launchers of existing types of SLBMs shall be incapable, without conversion, of launching ICBMs or SLBMs, respectively, of other types. [Agreed State 16]

6. Each Party undertakes not to convert SLBMs into ICBMs for mobile launchers of ICBMs, or to load SLBMs on, or launch SLBMs from, mobile launchers of ICBMs.

7. Each Party undertakes not to produce, test, or deploy transporter-loaders other than transporter-loaders for ICBMs for road-mobile launchers of ICBMs attributed with one warhead.

8. Each Party undertakes not to locate deployed silo launchers of ICBMs outside ICBM bases for silo launchers of ICBMs.

9. Each Party undertakes not to locate soft-site launchers except at test ranges and space launch facilities. All existing soft-site launchers not at test ranges or space launch facilities shall be eliminated in accordance with the procedures provided for in the Conversion or Elimination Protocol no later than 60 days after entry into force of this Treaty. [Agreed State 27]

10. Each Party undertakes not to:

(a) flight-test ICBMs or SLBMs of a retired or former type from other than test launchers specified for such use or launchers at space launch facilities. Except for soft-site launchers, test launchers specified for such use shall not be used to flight-test ICBMs or SLBMs of a type, any one of which is deployed; [III.10(c)]

(b) produce ICBMs for mobile launchers of ICBMs of a retired type.

11. Each Party undertakes not to convert silos used as launch control centers into silo launchers of ICBMs. [Silo LCC Letters]

12. Each Party undertakes not to:

(a) produce, flight-test, or deploy an ICBM or SLBM with more than ten reentry vehicles;

(b) flight-test an ICBM or SLBM with a number of reentry vehicles greater than the number of warheads attributed to it, or, for an ICBM or SLBM of a retired type, with a number of reentry vehicles greater than the largest number of warheads that was attributed to any ICBM or SLBM of that type;

(c) deploy an ICBM or SLBM with a number of reentry vehicles greater than the number of warheads attributed to it;

(d) increase the number of warheads attributed to an ICBM or SLBM of an existing or new type. [III.4(b)]

13. Each Party undertakes not to flight-test or deploy an ICBM or SLBM with a number of reentry vehicles greater than the number of warheads attributed to it. [Agreed State 3]

14. Each Party undertakes not to flight-test from space launch facilities ICBMs or SLBMs equipped with reentry vehicles.

15. Each Party undertakes not to use ICBMs or SLBMs for delivering objects into the upper atmosphere or space for purposes inconsistent with existing international obligations undertaken by the Parties.

16. Each Party undertakes not to produce, test, or deploy systems for rapid reload and not to conduct rapid reload.

17. Each Party undertakes not to install SLBM launchers on submarines that were not originally constructed as ballistic missile submarines. [US MOU Annex I]

18. Each Party undertakes not to produce, test, or deploy:

(a) ballistic missiles with a range in excess of 600 kilometers, or launchers of such missiles, for installation on waterborne vehicles, including free-floating launchers, other than submarines. This obligation shall not require changes in current ballistic missile storage, transport, loading, or unloading practices; [Agreed State 9] [Agreed State 30]

(b) launchers of ballistic or cruise missiles for emplacement on or for tethering to the ocean floor, the seabed, or the beds of internal waters and inland waters, or for emplacement in or for tethering to the subsoil thereof, or mobile launchers of such missiles that move only in contact with the ocean floor, the seabed, or the beds of internal waters and inland waters, or missiles for such launchers. This obligation shall apply to all areas of the ocean floor and the seabed, including the seabed zone referred to in Articles I and II of the Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Seabed and the Ocean Floor and in the Subsoil Thereof of February 11, 1971;

(c) systems, including missiles, for placing nuclear weapons or any other kinds of weapons of mass destruction into Earth orbit or a fraction of an Earth orbit;

(d) air-to-surface ballistic missiles (ASBMs); [Agreed State 4] [Agreed State 30]

(e) long-range nuclear ALCMs armed with two or more nuclear weapons. [ALCMs with Multiple Weapons Letters]

19. Each Party undertakes not to:

(a) flight-test with nuclear armaments an aircraft that is not an airplane, but that has a range of 8000 kilometers or more; equip such an aircraft for nuclear armaments; or deploy such an aircraft with nuclear armaments;

(b) flight-test with nuclear armaments an airplane that was not initially constructed as a bomber, but that has a range of 8000 kilometers or more, or an integrated planform area in excess of 310 square meters; equip such an airplane for nuclear armaments; or deploy such an airplane with nuclear armaments;

(c) flight-test with long-range nuclear ALCMs an aircraft that is not an airplane, or an airplane that was not initially constructed as a bomber; equip such an aircraft or such an airplane for long-range nuclear ALCMs; or deploy such an aircraft or such an airplane with long-range nuclear ALCMs.

20. The United States of America undertakes not to equip existing or future heavy bombers for more than 20 long-range nuclear ALCMs. [US MOU Annex G]

21. The Union of Soviet Socialist Republics undertakes not to equip existing or future heavy bombers for more than 16 long-range nuclear ALCMs. [RF MOU Annex G]

22. Each Party undertakes not to locate long-range nuclear ALCMs at air bases for heavy bombers equipped for nuclear armaments other than long-range nuclear ALCMs, air bases for heavy bmbers equipped for non-nuclear armaments, air bases for former heavy bombers, or training facilities for heavy bombers. [US MOU Annex C] [RF MOU Annex C] [TSSAM Statements]

23. Each Party undertakes not to base heavy bombers equipped for long-range nuclear ALCMs, heavy bombers equipped for nuclear armaments other than long-range nuclear ALCMs, or heavy bombers equipped for non-nuclear armaments at air bases at which heavy bombers of either of the other two categories are based. [US MOU Annex C] [RF MOU Annex C]

24. Each Party undertakes not to convert:

(a) heavy bombers equipped for nuclear armaments other than long-range nuclear ALCMs into heavy bombers equipped for long-range nuclear ALCM, if such heavy bombers were previously equipped for long-range nuclear ALCMs;

(b) heavy bombers equipped for non-nuclear armaments into heavy bombers equipped for long-range nuclear ALCM or into heavy bombers equipped for nuclear armaments other than long-range nuclear ALCMs;

(c) training heavy bombers into heavy bombers of another category;

(d) former heavy bombers into heavy bombers.

25. Each Party undertakes not to have underground facilities accessible to ballistic missile submarines. [Underground Submarine Facility Statements]

26. Each Party undertakes not to locate railcars at the site of a rail garrison that has been eliminated in accordance with Section IX of the Conversion or Elimination Protocol, unless such railcars have differences, observable by national technical means of verification, in length, width, or height from rail-mobile launchers of ICBMs or launch-associated railcars.

27. Each Party undertakes not to engage in any activities associated with strategic offensive arms at eliminated facilities, notification of the elimination of which has been provided in accordance with paragraph 3 of Section I of the Notification Protocol, unless notification of a new facility at the same location has been provided in accordance with paragraph 3 of Section I of the Notification Protocol. Strategic offensive arms and support equipment shall not be located at eliminated facilities except during their movement through such facilities and during visits of heavy bombers or former heavy bombers at such facilities. Missile tenders may be located at eliminated facilities only for purposes not associated with strategic offensive arms. [Statement on Launch-Associated/Driver Training Vehicles]

28. Each Party undertakes not to base strategic offensive arms subject to the limitations of this Treaty outside its national territory. [Agreed State 8] [Agreed State 18] [3rd Country Basing Letter]

29. Each Party undertakes not to use naval vessels that were formerly declared as missile tenders to transport, store, or load SLBMs. Such naval vessels shall not be tied to a ballistic missile submarines for the purpose of supporting such a submarine if such a submarine is located within five kilometers of a submarine base. [US MOU Annex B]

30. Each Party undertakes not to remove from production facilities for ICBMs for mobile launchers of ICBMs, solid rocket motors with attached nozzles for the first stages of ICBMs for mobile launchers of ICBMs, except for:

(a) the removal of such motors as part of assembled first stages of ICBMs for ICBMs for mobile launchers of ICBMs that are maintained, stored, and transported in stages; [RF MOU Annex F] [US MOU Annex F]

(b) the removal of such motors as part of assembled ICBMs for mobile launchers of ICBMs that are maintained, stored, and transported as assembled missiles in launch canisters or without launch canisters; and [RF MOU Annex F] [US MOU Annex F] [Agreed State 28]

(c) the removal of such motors as part of assembled first stages of ICBMs for mobile launchers of ICBMs that are maintained, stored, and transported as assembled missiles in launch canisters or without launch canisters, for the purpose of technical characteristics exhibitions. [RF MOU Annex F] [US MOU Annex F] [Agreed State 28]

ARTICLE VI

1. Deployed road-mobile launchers of ICBMs and their associated missiles shall be based only in restricted areas. A restricted area shall not exceed five square kilometers in size and shall not overlap another restricted area. No more than ten deployed road-mobile launchers of ICBMs and their associated missiles may be based or located in a restricted area. A restricted area shall not contain deployed ICBMs for road-mobile launchers of ICBMs of more than one type of ICBM. [RF MOU Annex A] [Agreed State 19]

2. Each Party shall limit the number of fixed structures for road-mobile launchers of ICBMs within each restricted areas so that these structures shall not be capable of containing more road-mobile launchers of ICBMs than the number of road-mobile launchers of ICBMs specified for that restricted area. [RF MOU Annex A]

3. Each restricted area shall be located within a deployment area. A deployment area shall not exceed 125,000 square kilometers in size and shall not overlap another deployment area. A deployment area shall contain no more than one ICBM base for road-mobile launchers of ICBMs. [RF MOU Annex A]

4. Deployed rail-mobile launchers of ICBMs and their associated missiles shall be based only in rail garrisons. Each Party shall have no more than seven rail garrisons. No point on a portion of track located inside a rail garrison shall be more than 20 kilometers from any entrance/exit for that rail garrison. This distance shall be measured along the tracks. A rail garrison shall not overlap another rail garrison. [RF MOU Annex A]

5. Each rail garrison shall have no more than two rail entrances/exits. Each such entrance/exit shall have no more than two separate sets of tracks passing through it (a total of four rails). [RF MOU Annex A]

6. Each Party shall limit the number of parking sites in each rail garrison to no more than the number of trains of standard configuration specified for that rail garrison. Each rail garrison shall have no more than five parking sites. [RF MOU Annex A] [RF MOU Annex F]

7. Each Party shall limit the number of fixed structures for rail-mobile launchers of ICBMs in each rail garrison to no more than the number of trains of standard configuration specified for that rail garrison. Each such structure shall contain no more than one train of standard configuration. [RF MOU Annex A] [RF MOU Annex F]

8. Each rail garrison shall contain no more than one maintenance facility. [RF MOU Annex A]

9. Deployed mobile launchers of ICBMs and their associated missiles may leave restricted areas or rail garrisons only for routine movements, relocations, or dispersals [XIII.1] [XIV.1]. Deployed road-mobile launchers of ICBMs and their associated missiles may leave deployment areas only for relocations or operational dispersals.

10. Relocations shall be completed within 25 days. No more than 15 percent of the total number of deployed road-mobile launchers of ICBMs and their associated missiles or five such launchers and their associated missiles, whichever is greater, may be outside restricted areas at any one time for the purpose of relocation. No more than 20 percent of the total number of deployed rail-mobile launchers of ICBMs and their associated missiles or five such launchers and their associated missiles, whichever is greater, may be outside rail garrisons at any one time for the purpose of relocation.

11. No more than 50 percent of the total number of deployed rail-mobile launchers of ICBMs and their associated missiles may be engaged in routine movements at any one time. [RF MOU Annex A]

12. All trains with deployed rail-mobile launchers of ICBMs and their associated missiles of a particular type shall be of one standard configuration. All such trains shall conform to that standard configuration except those taking part in routine movements, relocations, or dispersals, and except that portion of a train remaining within a rail garrisons after the other portion of such a train has departed for the maintenance facility associated with that rail garrison, has been relocated to another facility, or has departed the rail garrison for routine movement. Except for dispersals, notification of variations from standard configuration shall be provided in accordance with paragraphs 13, 14, and 15 of Section II of the Notification Protocol. [RF MOU Annex A] [RF MOU Annex F]

ARTICLE VII

1. Conversion and elimination of strategic offensive arms, fixed structures for mobile launchers of ICBMs, and facilities shall be carried out pursuant to this Article and in accordance with procedures provided for in the Conversion or Elimination Protocol. Conversion and elimination shall be verified by national technical means

of verification and by inspection as provided for in Articles IX and XI of this Treaty; in the Conversion or Elimination Protocol; and in the Protocol on Inspections and Continuous Monitoring Activities Relating to this Treaty, hereinafter referred to as the Inspection Protocol.

2. ICBMs for mobile launchers of ICBMs, ICBM launchers, SLBM launchers, heavy bombers, former heavy bombers, and support equipment shall be subject to the limitations provided for in this Treaty until they have been eliminated, or otherwise cease to be subject to the limitations provided for in this Treaty, in accordance with procedures provided for in the Conversion or Elimination Protocol. [Agreed State 11] [Agreed State 37] [Joint State Missile Production Technology]

3. ICBMs for silo launchers of ICBMs and SLBMs shall be subject to the limitations provided for in this Treaty until they have been eliminated by rendering them inoperable, precluding their use for their original purpose, using procedures at the discretion of the Party possessing the ICBMs or SLBMs.

4.The elimination of ICBMs for mobile launchers of ICBMs, mobile launchers of ICBMs, SLBM launchers, heavy bombers, and former heavy bombers [Agreed State 10]shall be carried out at conversion or elimination facilities, except as provided for in Sections VII and VIII of the Conversion or Elimination Protocol. Fixed launchers of ICBMs and fixed structures for mobile launchers of ICBMs subject to elimination shall be eliminated in situ. A launch canister [Launch Canister Letters] [Agreed State 20] remaining at a test range or ICBM base after the flight test of an ICBM for mobile launchers of ICBMs shall be eliminated in the open in situ, or at a conversion or elimination facility, in accordance with procedures provided for in the Conversion or Elimination Protocol. [Agreed State 37]

ARTICLE VIII

1. A data base pertaining to the obligations under this Treaty is set forth in the Memorandum of Understanding, in which data with respect to items subject to the limitations provided for in this Treaty are listed according to categories of data. [MOU, Annex J] [Joint State Data Updates] [Agreed State 37]

2. In order to ensure the fulfillment of its obligations with respect to this Treaty, each Party shall notify the other Party of changes in data, as provided for in subparagraph 3(a) of this Article, and shall also provide other notifications required by paragraph 3 of this Article, in accordance with the procedures provided for in paragraphs 4, 5, and 6 of this Article, the Notification Protocol, and the Inspection Protocol.

3. Each Party shall provide to the other Party, in accordance with the Notification Protocol, and, for subparagraph (i) of this paragraph, in accordance with Section III of the Inspection Protocol: [Agreed State 37]

(a) notifications concerning data with respect to items subject to the limitations provided for in this Treaty, according to categories of data contained in the Memorandum of Understanding and other agreed categories of data; [Agreed State 21]

(b) notifications concerning movement of items subject to the limitations provided for in this Treaty;

(c) notifications concerning data on ICBM and SLBM throw-weight in connection with the Protocol on ICBM and SLBM Throw-weight [MOU, Section I] Relating to this Treaty, hereinafter referred to as the Throw-weight Protocol;

(d) notifications concerning conversion or elimination of items subject to the limitations provided for in this Treaty or elimination of facilities subject to this Treaty;

(e) notifications concerning cooperative measures to enhance the effectiveness of national technical means of verification;

(f) notifications concerning flight tests of ICBMs or SLBMs and notifications concerning telemetric information; [Launch Notification Agreement]

(g) notifications concerning strategic offensive arms of new types and new kinds; [Agreed State 2]

(h) notifications concerning changes in the content of information provided pursuant to this paragraph, including the rescheduling of activities;

(i) notifications concerning inspections and continuous monitoring activities; and

(j) notifications concerning operational dispersals.

4. Each Party shall use the Nuclear Risk Reduction Centers, which provide for continuous communication between the Parties, to provide and receive notifications in accordance with the Notification Protocol and the Inspection Protocol, unless otherwise provided for in this Treaty, and to acknowledge receipt of such notifications no later than one hour after receipt.

5. If a time is to be specified in a notification provided pursuant to this Article, that time shall be expressed in Greenwich Mean Time. If only a date is to be specified in a notification, that date shall be specified as the 24-hour period that corresponds to the date in local time, expressed in Greenwich Mean Time.

6. Except as otherwise provided in this Article, each Party shall have the right to release to the public all data current as of September 1, 1990, that are listed in the Memorandum of Understanding, as well as the photographs that are appended thereto. Geographic coordinates and site diagrams that are received pursuant to the Agreement Between the Government of the United States

of America and the Government of the Union of Soviet Socialist Republics on Exchange of Geographic Coordinates and Site Diagrams Relating to the Treaty of July 31, 1991, shall not be released to the public unless otherwise agreed. The Parties shall hold consultations on releasing to the public data and other information provided pursuant to this Article or received otherwise in fulfilling the obligations provided for in this Treaty. The provisions of this Article shall not affect the rights and obligations of the Parties with respect to the communication of such data and other information to those individuals who, because of their official responsibilities, require such data or other information to carry out activities related to the fulfillment of the obligations provided for in this Treaty. [Statements on Release to Public]

ARTICLE IX

1. For the purpose of ensuring verification of compliance with the provisions of this Treaty, each Party shall use national technical means of verification at its disposal in a manner consistent with generally recognized principles of international law.

2. Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph l of this Article.

3. Each Party undertakes not to use concealment measures that impede verification, by national technical means of verification, of compliance with the provisions of this Treaty. In this connection, the obligation not to use concealment measures includes the obligation not to use them at test ranges, including measures that result in the concealment of ICBMs, SLBMs, mobile launchers of ICBMs, or the association between ICBMs or SLBMs and their launchers during testing. The obligation not to use concealment measures shall not apply to cover or concealment practices at ICBM bases and deployment areas, or to the use of environmental shelters for strategic offensive arms.

4. To aid verification, each ICBM for mobile launchers of ICBMs shall have a unique identifier as provided for in the Inspection Protocol.

ARTICLE X

1. During each flight test of an ICBM or SLBM, the Party conducting the flight test shall make on-board technical measurements and shall broadcast all telemetric information obtained from such measurements. The Party conducting the flight test shall determine which technical parameters are to be measured during such flight test, as well as the methods of processing and transmitting telemetric information.

2. During each flight test of an ICBM or SLBM, the Party conducting the flight test undertakes not to engage in any activity that denies full access to telemetric information, including: [Statements on Encryption & Jamming]

(a) the use of encryption;

(b) the use of jamming;

(c) broadcasting telemetric information from an ICBM or SLBM using narrow directional beaming; and

(d) encapsulation of telemetric information, including the use of ejectable capsules or recoverable reentry vehicles.

3. During each flight test of an ICBM or SLBM, the Party conducting the flight test undertakes not to broadcast from a reentry vehicles. telemetric information that pertains to the functioning of the stages or the self-contained dispensing mechanism of the ICBM or SLBM.

4. After each flight test of an ICBM or SLBM, the Party conducting the flight test shall provide, in accordance with Section I of the Protocol on Telemetric Information Relating to the Treaty, hereinafter referred to as the Telemetry Protocol, tapes nthat contain a recording of all telemetric information that is broadcast during the flight test.

5. After each flight test of an ICBM or SLBM, the Party conducting the flight test shall provide, in accordance with Section II of the Telemetry Protocol, data associated with the analysis of the telemetric information. [Agreed State 35]

6. Notwithstanding the provisions of paragraphs 1 and 2 of this Article, each Party shall have the right to encapsulate and encrypt on-board technical measurements during no more than a total of eleven flight tests of ICBMs or SLBMs each year. Of these eleven flight tests each year, no more than four shall be flight tests of ICBMs or SLBMs of each type, any missile of which has been flight-tested with a self-contained dispensing mechanism. Such encapsulation shall be carried out in accordance with Section I and paragraph 1 of Section III of the Telemetry Protocol, and such encryption shall be carried out in accordance with paragraph 2 of Section III of the Telemetry Protocol. Encapsulation and encryption that are carried out on the same flight test of an ICBM or SLBM shall count as two flight tests against the quotas specified in this paragraph. [Agreed State 31]

ARTICLE XI

1. For the purpose of ensuring verification of compliance with the provisions of this Treaty, each Party shall have

the right to conduct inspections and continuous monitoring activities and shall conduct exhibitions pursuant to this Article and the Inspection Protocol. Inspections, continuous monitoring activities, and exhibitions shall be conducted in accordance with the procedures provided for in the Inspection Protocol and the Conversion or Elimination Protocol. [item of inspection] [size criteria] [Agreed State 36]

2. Each Party shall have the right to conduct baseline data inspections at facilities to confirm the accuracy of data on the numbers and types of items specified for such facilities in the initial exchange of data provided in accordance with paragraph 1 of Section I of the Notification Protocol. [facility inspections at] [Agreed State 10]

3. Each Party shall have the right to conduct data update inspections at facilities to confirm the accuracy of data on the numbers and types of items specified for such facilities in the notifications and regular exchanges of updated data provided in accordance with paragraphs 2 and 3 of Section I of the Notification Protocol. [facility inspections at] [Agreed State 10]

4. Each Party shall have the right to conduct new facility inspections to confirm the accuracy of data on the numbers and types of items specified in the notifications of new facilities provided in accordance with paragraph 3 of Section I of the Notification Protocol. [facility inspections at]

5. Each Party shall have the right to conduct suspect-site inspections to confirm that covert assembly of ICBMs for mobile launchers of ICBMs or covert assembly of first stages of such ICBMs is not occurring. [facility inspections at] [RF MOU Annex I] [US MOU Annex I] [Joint State on Site Diagrams]

6. Each Party shall have the right to conduct reentry vehicle inspections of deployed ICBMs and SLBMs to confirm that such ballistic missiles contain no more reentry vehicles than the number of warheads attributed to them. [facility inspections at] [RF MOU Section I] [US MOU Section I]

7. Each Party shall have the right to conduct post-exercise dispersal inspections of deployed mobile launchers of ICBMs and their associated missiles to confirm that the number of mobile launchers of ICBMs and their associated missiles that are located at the inspected ICBM bases and those that have not returned to it after completion of the dispersal does not exceed the number specified for that ICBM base.

8. Each Party shall conduct or shall have the right to conduct conversion or elimination inspections to confirm the conversion or elimination of strategic offensive arms.

9. Each Party shall have the right to conduct close-out inspections to confirm that the elimination of facilities has been completed.

10. Each Party shall have the right to conduct formerly declared facility inspections to confirm that facilities, notification of the elimination of which has been provided in accordance with paragraph 3 of Section I of the Notification Protocol, are not being used for purposes inconsistent with this Treaty.

11. Each Party shall conduct technical characteristics exhibitions, and shall have the right during such exhibitions by the other Party to conduct inspections of an ICBM and an SLBM of each type, and each variant thereof, and of a mobile launcher of ICBMs and each version of such launcher for each type of ICBM for mobile launchers of ICBMs. The purpose of such exhibitions shall be to permit the inspecting Party to confirm that technical characteristics correspond to the data specified for these items. [RF MOU Annex F] [US MOU Annex F] [Agreed State 25] [Early Exhibitions Agreement] [Agreed State 28]

12. Each Party shall conduct distinguishability exhibitions for heavy bombers, former heavy bombers, and long-range nuclear ALCMs, and shall have the right during such exhibitions by the other Party to conduct inspections, of: [Agreed State 10]

(a) heavy bombers equipped for long-range nuclear ALCMs. The purpose of such exhibitions shall be to permit the inspecting Party to confirm that the technical characteristics of each type and each variant of such heavy bombers correspond to the data specified for these items in Annex G to the Memorandum of Understanding; to demonstrate the maximum number of long-range nuclear ALCMs for which a heavy bomber of each type and each variant is actually equipped; and to demonstrate that this number does not exceed the number provided for in paragraph 20 or21 of Article V of this Treaty, as applicable; [RF MOU Annex G] [US MOU Annex G]

(b) for each type of heavy bomber from any one of which a long-range nuclear ALCM has been flight-tested, heavy bombers equipped for nuclear armaments other than long-range nuclear ALCMs, heavy bombers equipped for non-nuclear armaments, training heavy bombers, and former heavy bombers. If, for such a type of heavy bomber, there are no heavy bombers equipped for long-range nuclear ALCMs, a test heavy bomber from which a long-range nuclear ALCM has been flight-tested shall be exhibited. The purpose of such exhibitions shall be to demonstrate to the inspecting Party that, for each exhibited type of heavy bomber, each variant of heavy bombers equipped for nuclear armaments other than long-range nuclear ALCMs, each variant of heavy bombers equipped for non-nuclear armaments, each variant of training heavy bombers, and a former heavy bomber are distinguishable from one another and from each variant of heavy bombers of the same type equipped for long-range nuclear ALCMs; and [RF MOU Annex G] [US MOU Annex G]

(c) long-range nuclear ALCMs. The purpose of such exhibitions shall be to permit the inspecting Party to confirm that the technical characteristics of each type and each variant of such long-range ALCMs correspond to the data specified for these items in Annex H to the Memorandum of Understanding. The further purpose of such exhibitions shall be to demonstrate differences, notification of which has been provided in accordance with paragraph 13, 14, or 15 of Section VII of the Notification Protocol, that make long-range non-nuclear ALCMs distinguishable from long-range nuclear ALCMs. [RF MOU Annex H] [US MOU Annex H]

13. Each Party shall conduct baseline exhibitions, and shall have the right during such exhibitions by the other Party to conduct inspections, of all heavy bombers equipped for long-range nuclear ALCMs equipped for non-nuclear armaments, all training heavy bombers, and all former heavy bombers specified in the initial exchange of data provided in accordance with paragraph 1 of Section I of the Notification Protocol. The purpose of these exhibitions shall be to demonstrate to the inspecting Party that such airplanes satisfy the requirements for conversion in accordance with the Conversion or Elimination Protocol. After a long-range nuclear ALCM has been flight-tested from a heavy bomber of a type, from none of which a long-range nuclear ALCM had previously been flight-tested, the Party conducting the flight test shall conduct baseline exhibitions, and the other Party shall have the right during such exhibitions to conduct inspections, of 30 percent of the heavy bombers equipped for long-range nuclear ALCMs of such type equipped for nuclear armaments other than long-range nuclear ALCMs at each air base specified for such heavy bombers. The purpose of these exhibitions shall be to demonstrate to the inspecting Party the presence of specified features that make each exhibited heavy bomber distinguishable from heavy bombers of the same type equipped for long-range nuclear ALCMs.

14. Each Party shall have the right to conduct continuous monitoring activities at production facilities for ICBMs for mobile launchers of ICBMs to confirm the number of ICBMs for mobile launchers of ICBMs produced. [Agreed State 22] [facilities] [Site Surveys Letters]

ARTICLE XII

1. To enhance the effectiveness of national technical means of verification, each Party shall, if the other Party makes a request in accordance with paragraph 1 of Section V of the Notification Protocol, carry out the following cooperative measures:

(a) a display in the open of the road-mobile launchers of ICBMs located within restricted areas specified by the requesting Party. The number of road-mobile launchers of ICBMs based at the restricted areas specified in each such request shall not exceed ten percent of the total number of deployed road-mobile launchers of ICBMs of the requested Party, and such launchers shall be contained within one ICBM base for road-mobile launchers of ICBMs. For each specified restricted area, the roofs of fixed structures for road-mobile launchers of ICBMs shall be open for the duration of a display. The road-mobile launchers of ICBMs located within the restricted area shall be displayed either located next to or moved halfway out of such fixed structures; [RF MOU Annex A]

(b) a display in the open of the rail-mobile launchers of ICBMs located at parking sites specified by the requesting Party. Such launchers shall be displayed by removing the entire train from its fixed structure and locating the train within the rail garrison. The number of rail-mobile launchers of ICBMs subject to display pursuant to each such request shall include all such launchers located at no more than eight parking sites, provided that no more than two parking sites may be requested within any one rail garrison in any one request. Requests concerning specific parking sites shall include the designation for each parking site as provided for in Annex A to the Memorandum of Understanding; and [RF MOU Annex A]

(c) a display in the open of all heavy bombers and former heavy bombers located within one air base specified by the requesting Party, except those heavy bombers and former heavy bombers that are not readily movable due to maintenance or operations. Such heavy bombers and former heavy bombers shall be displayed by removing the entire airplane from its fixed structure, if any, and locating the airplane within the air base. Those heavy bombers and former heavy bombers at the air base specified by the requesting Party that are not readily movable due to maintenance or operations shall be specified by the requested Party in a notification provided in accordance with paragraph 2 of Section V of the Notification Protocol. Such a notification shall be provided no later than 12 hours after the request for display has been made.

2. Road-mobile launchers of ICBMs, rail-mobile launchers of ICBMs, heavy bombers, and former heavy bombers subject to each request pursuant to paragraph 1 of this Article shall be displayed in open view without using concealment measures. Each Party shall have the right to make seven such requests each year, but shall not request a display at any particular ICBM base for road-mobile launchers of ICBMs, any particular parking site, or any particular air base more than two times each year.

A Party shall have the right to request, in any single request, only a display of road-mobile launchers of ICBMs, a display of rail-mobile launchers of ICBMs, or a display of heavy bombers and former heavy bombers. A display shall begin no later than 12 hours after the request is made and shall continue until 18 hours have elapsed from the time that the request was made. If the requested Party cannot conduct a display due to circumstances brought about by force majeure, it shall provide notification to the requesting Party in accordance with paragraph 3 of Section V of the Notification Protocol, and the display shall be cancelled. In such a case, the number of requests to which the requesting Party is entitled shall not be reduced.

3. A request for cooperative measures shall not be made for a facility that has been designated for inspection until such an inspection has been completed and the inspectors have departed the facility. A facility for which cooperative measures have been requested shall not be designated for inspection until the cooperative measures have been completed or until notification has been provided in accordance with paragraph 3 of Section V of the Notification Protocol.

ARTICLE XIII

1. Each Party shall have the right to conduct exercise dispersal of deployed mobile launchers of ICBMs and their associated missiles from restricted areas or rail garrisons. Such an exercise dispersal may involve either road-mobile launchers of ICBMs or rail-mobile launchers of ICBMs, or both road-mobile launchers of ICBMs and rail-mobile launchers of ICBMs. Exercise dispersals of deployed mobile launchers of ICBMs and their associated missiles shall be conducted as provided for below:

(a) An exercise dispersal shall be considered to have begun as of the date and time specified in the notification provided in accordance with paragraph 11 of Section II of the Notification Protocol.

(b) An exercise dispersal shall be considered to be completed as of the date and time specified in the notification provided in accordance with paragraph 12 of Section II of the Notification Protocol.

(c) Those ICBM bases for mobile launchers of ICBMs specified in the notification provided in accordance with paragraph 11 of Section II of the Notification Protocol shall be considered to be involved in an exercise dispersal.

(d) When an exercise dispersal begins, deployed mobile launchers of ICBMs and their associated missiles engaged in a routine movement from a restricted area or rail garrison of an ICBM base for mobile launchers of ICBMs that is involved in such a dispersal shall be considered to be part of the dispersal.

(e) When an exercise dispersal begins, deployed mobile launchers of ICBMs and their associated missiles engaged in a relocation from a restricted area or rail garrisons of an ICBM base for mobile launchers of ICBMs that is involved in such a dispersal shall continue to be considered to be engaged in a relocation. Notification of the completion of the relocation shall be provided in accordance with paragraph 10 of Section II of the Notification Protocol, unless notification of the completion of the relocation was provided in accordance with paragraph 12 of Section II of the Notification Protocol.

(f) During an exercise dispersal, all deployed mobile launchers of ICBMs and their associated missiles that depart a restricted area or rail garrison of an ICBM base for mobile launchers of ICBMs involved in such a dispersal shall be considered to be part of the dispersal, except for such launchers and missiles that relocate to a facility outside their associated ICBM base during such a dispersal.

(g) An exercise dispersal shall be completed no later than 30 days after it begins.

(h) Exercise dispersals shall not be conducted:

(i) more than two times in any period of two calendar years;

(ii) during the entire period of time provided for baseline data inspections;

(iii) from a new ICBM base for mobile launchers of ICBMs until a new facility inspection has been conducted or until the period of time provided for such an inspection has expired; or

(iv) from an ICBM base for mobile launchers of ICBMs that has been designated for a data update inspection or reentry vehicle inspection, until completion of such an inspection.

(i) If a notification of an exercise dispersal has been provided in accordance with paragraph 11 of Section II of the Notification Protocol, the other Party shall not have the right to designate for data update inspection or reentry vehicle inspection an ICBM base for mobile launchers of ICBMs involved in such a dispersal, or to request cooperative measures for such an ICBM base, until the completion of such a dispersal.

(j) When an exercise dispersal is completed, deployed mobile launchers of ICBMs and their associated missiles involved in such a dispersal shall be located at their restricted areas or rail garrisons, except for those otherwise accounted for in accordance with paragraph 12 of Section II of the Notification Protocol.

2. A major strategic exercise involving heavy bombers, about which a notification has been provided pursuant to the Agreement Between the Government of the United States of America and the Government of the Union of Soviet Socialist Republics on Reciprocal Advance Notification of Major Strategic Exercises of September 23, 1989, shall be conducted as provided for below:

(a) Such exercise shall be considered to have begun as of the date and time specified in the notification provided in accordance with paragraph 16 of Section II of the Notification Protocol.

(b) Such exercise shall be considered to be completed as of the date and time specified in the notification provided in accordance with paragraph 17 of Section II of the Notification Protocol.

(c) The air bases for heavy bombers and air bases for former heavy bombers specified in the notification provided in accordance with paragraph 16 of Section II of the Notification Protocol shall be considered to be involved in such exercise.

(d) Such exercise shall begin no more than one time in any calendar year, and shall be completed no later than 30 days after it begins.

(e) Such exercise shall not be conducted during the entire period of time provided for baseline data inspections.

(f) During such exercise by a Party, the other Party shall not have the right to conduct inspections of the air bases for heavy bombers and air bases for former heavy bombers involved in the exercise. The right to conduct inspections of such air bases shall resume three days after notification of the completion of a major strategic exercise involving heavy bombers has been provided in accordance with paragraph 17 of Section II of the Notification Protocol.

(g) Within the 30-day period following the receipt of the notification of the completion of such exercise, the receiving Party may make a request for cooperative measures to be carried out in accordance with subparagraph 1(c) of Article XII of this Treaty at one of the air bases involved in the exercise. Such a request shall not be counted toward the quota provided for in paragraph 2 of Article XII of this Treaty.

ARTICLE XIV

1. Each Party shall have the right to conduct operational dispersals of deployed mobile launchers of ICBMs and their associated missiles, ballistic missile submarines, and heavy bombers. There shall be no limit on the number and duration of operational dispersals, and there shall be no limit on the number of deployed mobile launchers of ICBMs and their associated missiles, ballistic missile submarines, or heavy bombers involved in such dispersals. When an operational dispersal begins, all strategic offensive arms of a Party shall be considered to be part of the dispersal. Operational dispersals shall be conducted as provided for below: [Agreed State 7]

(a) An operational dispersal shall be considered to have begun as of the date and time specified in the notification provided in accordance with paragraph 1 of Section X of the Notification Protocol.

(b) An operational dispersal shall be considered to be completed as of the date and time specified in the notification provided in accordance with paragraph 2 of Section X of the Notification Protocol.

2. During an operational dispersal each Party shall have the right to:

(a) suspend notifications that it would otherwise provide in accordance with the Notification Protocol except for notification of flight tests provided under the Agreement Between the United States of America and the Union of Soviet Socialist Republics on Notifications of Launches of Intercontinental Ballistic Missiles and Submarine-Launched Ballistic Missiles of May 31, 1988; provided that, if any conversion or elimination processes are not suspended pursuant to subparagraph (d) of this paragraph, the relevant notifications shall be provided in accordance with Section IV of the Notification Protocol;

(b) suspend the right of the other Party to conduct inspections;

(c) suspend the right of the other Party to request cooperative measures; and

(d) suspend conversion and elimination processes for its strategic offensive arms. In such case, the number of converted and eliminated items shall correspond to the number that has actually been converted and eliminated as of the date and time of the beginning of the operational dispersal specified in the notification provided in accordance with paragraph 1 of Section X of the Notification Protocol.

3. Notifications suspended pursuant to paragraph 2 of this Article shall resume no later than three days after notification of the completion of the operational dispersal has been provided in accordance with paragraph 2 of Section X of the Notification Protocol. The right to conduct inspections and to request cooperative measures suspended pursuant to paragraph 2 of this Article shall resume four days after notification of the completion of the operational dispersal has been provided in accordance with paragraph 2 of Section X of the Notification Protocol. Inspections or cooperative measures being conducted at the time a Party provides notification that it suspends inspections or cooperative measures during an operational dispersal shall not count toward the appropriate annual quotas provided for by this Treaty.

4. When an operational dispersal is completed:

(a) All deployed road-mobile launchers of ICBMs and their associated missiles shall be located within their deployment areas or shall be engaged in relocations .

(b) All deployed rail-mobile launchers of ICBMs and their associated missiles shall be located within their rail garrisons or shall be engaged in routine movements or relocations .

(c) All heavy bombers shall be located within national territory and shall have resumed normal operations. If it is necessary for heavy bombers to be located outside national territory for purposes not inconsistent with this Treaty, the Parties will immediately engage in diplomatic consultations so that appropriate assurances can be provided.

5. Within the 30 day period after the completion of an operational dispersal, the Party not conducting the operational dispersal shall have the right to make no more than two requests for cooperative measures, subject to the provisions of Article XII of this Treaty, for ICBM bases for mobile launchers of ICBMs or air bases. Such requests shall not count toward the quota of requests provided for in paragraph 2 of Article XII of this Treaty.

ARTICLE XV

To promote the objectives and implementation of the provisions of this Treaty, the Parties hereby establish the Joint Compliance and Inspection Commission. The Parties agree that, if either Party so requests, they shall meet within the framework of the Joint Compliance and Inspection Commission to: [Lisbon Protocol]

(a) resolve questions relating to compliance with the obligations assumed;

(b) agree upon such additional measures as may be necessary to improve the viability and effectiveness of this Treaty; and

(c) resolve questions related to the application of relevant provisions of this Treaty to a new kind of strategic offensive arm, after notification has been provided in accordance with paragraph 16 of Section VII of the Notification Protocol.

ARTICLE XVI

To ensure the viability and effectiveness of this Treaty, each Party shall not assume any international obligations or undertakings that would conflict with its provisions. The Parties shall hold consultations in accordance with Article XV of this Treaty in order to resolve any ambiguities that may arise in this regard. The Parties [Lisbon Protocol] agree that this provision does not apply to any patterns of cooperation, including obligations, in the area of strategic offensive arms, existing at the time of signature of this Treaty, between a Party and a third State. [Agreed State 1] [Soviet State on Non-Circumvention & Patterns of Coop]

ARTICLE XVII

1. This Treaty, including its Annexes, Protocols, and Memorandum of Understanding, all of which form integral parts thereof, shall be subject to ratification in accordance with the constitutional procedures of each Party. This Treaty shall enter into force on the date of the exchange of instruments of ratification.

2. This Treaty shall remain in force for 15 years unless superseded earlier by a subsequent agreement on the reduction and limitation of strategic offensive arms. No later than one year before the expiration of the 15-year period, the Parties shall meet to consider whether this Treaty will be extended. If the Parties so decide, this Treaty will be extended for a period of five years unless it is superseded before the expiration of that period by a subsequent agreement on the reduction and limitation of strategic offensive arms. This Treaty shall be extended for successive five-year periods, if the Parties so decide, in accordance with the procedures governing the initial extension, and it shall remain in force for each agreed five-year period of extension unless it is superseded by a subsequent agreement on the reduction and limitation of strategic offensive arms.

3. Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests. It shall give notice of its decision to the other Party six months prior to withdrawal from this Treaty. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests.

ARTICLE XX

Each Party may propose amendments to this Treaty. Agreed amendments shall enter into force in accordance with the procedures governing entry into force of this Treaty.

ARTICLE XXI

This Treaty shall be registered pursuant to Article 102 of the Charter of the United Nations.

Done at Moscow on July 31, 1991, in two copies, each in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES OF AMERICA: George Bush

President of the United States of America

FOR THE UNION OF SOVIET SOCIALIST REPUBLICS: M. Gorbachev

President of the Union of Soviet Socialist Republics

Treaty Between the United States of America and the Russian Federation on Further Reduction and Limitation of Strategic Offensive Arms (START II)

January 3, 1993

The United States of America and the Russian Federation, hereinafter referred to as the Parties,

REAFFIRMING their obligations under the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Reduction and Limitation of Strategic Offensive Arms of July 31, 1991, hereinafter referred to as the START Treaty,

STRESSING their firm commitment to the Treaty on the Non-Proliferation of Nuclear Weapons of July 1, 1968, and their desire to contribute to its strengthening,

TAKING into account the commitment by the Republic of Belarus, the Republic of Kazakhstan, and Ukraine to accede to the Treaty on the Non-Proliferation of Nuclear Weapons of July 1, 1968, as non-nuclear-weapon States Parties,

MINDFUL of their undertakings with respect to strategic offensive arms under Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons of July 1, 1968, and under the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems of May 26, 1972, as well as the provisions of the Joint Understanding signed by the Presidents of the United States of America and the Russian Federation on June 17, 1992, and of the Joint Statement on a Global Protection System signed by the Presidents of the United States of America and the Russian Federation on June 17, 1992,

DESIRING to enhance strategic stability and predictability, and, in doing so, to reduce further strategic offensive arms, in addition to the reductions and limitations provided for in the START Treaty,

CONSIDERING that further progress toward that end will help lay a solid foundation for a world order built on democratic values that would preclude the risk of outbreak of war,

RECOGNIZING their special responsibility as permanent members of the United Nations Security Council for maintaining international peace and security,

TAKING note of United Nations General Assembly Resolution 47/52K of December 9, 1992.

CONSCIOUS of the new realities that have transformed the political and strategic relations between the Parties, and the relations of partnership that have been established between them,

Have agreed as follows:

ARTICLE I

1. Each Party shall reduce and limit its intercontinental ballistic missiles (ICBMs) and ICBM launchers, submarine-launched ballistic missiles (SLBMs) and SLBM launchers, heavy bombers, ICBM warheads, SLBM warheads, and heavy bomber armaments, so that seven years after entry into force of the START Treaty and thereafter, the aggregate number for each Party, as counted in accordance with Articles III and IV of this Treaty, does not exceed, for warheads attributed to deployed ICBMs, deployed SLBMs, and deployed heavy bombers, a number between 3800 and 4250 or such lower number as each Party shall decide for itself, but in no case shall such number exceed 4250.
2. Within the limitations provided for in paragraph 1 of this Article, the aggregate numbers for each Party shall not exceed:
(a) 2160, for warheads attributed to deployed SLBMs;
(b) 1200, for warheads attributed to deployed ICBMs of types to which more than one warhead is attributed; and
(c) 650, for warheads attributed to deployed heavy ICBMs.
3. Upon fulfillment of the obligations provided for in paragraph 1 of this Article, each Party shall further reduce and limit its ICBMs and ICBM launchers, SLBMs and SLBM launchers, heavy bombers, ICBM warheads, SLBM warheads, and heavy bomber armaments, so that no later than January 1, 2003, and thereafter, the aggregate number for each Party, as counted in accordance with Articles III and IV of this Treaty, does not exceed, for warheads attributed to deployed ICBMs, deployed SLBMs, and deployed heavy bombers, a number between 3000 and 3500 or such lower number as each Party shall decide for itself, but in no case shall such number exceed 3500.
4. Within the limitations provided for in paragraph 3 of this Article, the aggregate numbers for each Party shall not exceed:

(a) a number between 1700 and 1750, for warheads attributed to deployed SLBMs or such lower number as each Party shall decide for itself, but in no case shall such number exceed 1750;
(b) zero, for warheads attributed to deployed ICBMs of types to which more than one warhead is attributed; and
(c) zero, for warheads attributed to deployed heavy ICBMs.

5. The process of reductions provided for in paragraphs 1 and 2 of this Article shall begin upon entry into force of this Treaty, shall be sustained throughout the reductions period provided for in paragraph 1 of this Article, and shall be completed no later than seven years after entry into force of the START Treaty. Upon completion of these reductions, the Parties shall begin further reductions provided for in paragraphs 3 and 4 of this Article, which shall also be sustained throughout the reductions period defined in accordance with paragraphs 3 and 6 of this Article.
6. Provided that the Parties conclude, within one year after entry into force of this Treaty, an agreement on a program of assistance to promote the fulfillment of the provisions of this Article, the obligations provided for in paragraphs 3 and 4 of this Article and in Article II of this Treaty shall be fulfilled by each Party no later than December 31, 2000.

ARTICLE II

1. No later than January 1, 2003, each Party undertakes to have eliminated or to have converted to launchers of ICBMs to which one warhead is attributed all its deployed and non-deployed launchers of ICBMs to which more than one warhead is attributed under Article III of this Treaty (including test launchers and training launchers), with the exception of those launchers of ICBMs other than heavy ICBMs at space launch facilities allowed under the START Treaty, and not to have thereafter launchers of ICBMs to which more than one warhead is attributed. ICBM launchers that have been converted to launch an ICBM of a different type shall not be capable of launching an ICBM of the former type. Each Party shall carry out such elimination or conversion using the procedures provided for in the START Treaty, except as otherwise provided for in paragraph 3 of this Article.
2. The obligations provided for in paragraph 1 of this Article shall not apply to silo launchers of ICBMs on which the number of warheads has been reduced to one pursuant to paragraph 2 of Article III of this Treaty.
3. Elimination of silo launchers of heavy ICBMs, including test launchers and training launchers, shall be implemented by means of either:
(a) elimination in accordance with the procedures provided for in Section II of the Protocol on Procedures Governing the Conversion or Elimination of the Items Subject to the START Treaty; or
(b) conversion to silo launchers of ICBMs other than heavy ICBMs in accordance with the procedures provided for in the Protocol on Procedures Governing Elimination of Heavy ICBMs and on Procedures Governing Conversion of Silo Launchers of Heavy ICBMs Relating to the Treaty Between the United States of America and the Russian Federation on Further Reduction and Limitation of Strategic Offensive Arms, hereinafter referred to as the Elimination and Conversion Protocol. No more than 90 silo launchers of heavy ICBMs may be so converted.
4. Each Party undertakes not to emplace an ICBM, the launch canister of which has a diameter greater than 2.5 meters, in any silo launcher of heavy ICBMs converted in accordance with subparagraph 3(b) of this Article.
5. Elimination of launchers of heavy ICBMs at space launch facilities shall only be carried out in accordance with subparagraph 3(a) of this Article.
6. No later than January 1, 2003, each Party undertakes to have eliminated all of its deployed and non-deployed heavy ICBMs and their launch canisters in accordance with the procedures provided for in the Elimination and Conversion Protocol or by using such missiles for delivering objects into the upper atmosphere or space, and not to have such missiles or launch canisters thereafter.
7. Each Party shall have the right to conduct inspections in connection with the elimination of heavy ICBMs and their launch canisters, as well as inspections in connection with the conversion of silo launchers of heavy

ICBMs. Except as otherwise provided for in the Elimination and Conversion Protocol, such inspections shall be conducted subject to the applicable provisions of the START Treaty.

8. Each Party undertakes not to transfer heavy ICBMs to any recipient whatsoever, including any other Party to the START Treaty.
9. Beginning on January 1, 2003, and thereafter, each Party undertakes not to produce, acquire, flight-test (except for flight tests from space launch facilities conducted in accordance with the provisions of the START Treaty), or deploy ICBMs to which more than one warhead is attributed under Article III of this Treaty.

ARTICLE III

1. For the purposes of attributing warheads to deployed ICBMs and deployed SLBMs under this Treaty, the Parties shall use the provisions provided for in Article III of the START Treaty, except as otherwise provided for in paragraph 2 of this Article.
2. Each Party shall have the right to reduce the number of warheads attributed to deployed ICBMs or deployed SLBMs only of existing types, except for heavy ICBMs. Reduction in the number of warheads attributed to deployed ICBMs and deployed SLBMs of existing types that are not heavy ICBMs shall be carried out in accordance with the provisions of paragraph 5 of Article III of the START Treaty, except that:
(a) the aggregate number by which warheads are reduced may exceed the 1250 limit provided for in paragraph 5 of Article III of the START Treaty;
(b) the number by which warheads are reduced on ICBMs and SLBMs, other than the Minuteman III ICBM for the United States of America and the SS-N-18 SLBM for the Russian Federation, may at any one time exceed the limit of 500 warheads for each Party provided for in subparagraph 5(c)(I) of Article III of the START Treaty;
(c) each Party shall have the right to reduce by more than four warheads, but not by more than five warheads, the number of warheads attributed to each ICBM out of no more than 105 ICBMs of one existing type of ICBM. An ICBM to which the number of warheads attributed has been reduced in accordance with this paragraph shall only be deployed in an ICBM launcher in which an ICBM of that type was deployed as of the date of signature of the START Treaty; and
(d) the reentry vehicle platform for an ICBM or SLBM to which a reduced number of warheads is attributed is not required to be destroyed and replaced with a new reentry vehicle platform.
3. Notwithstanding the number of warheads attributed to a type of ICBM or SLBM in accordance with the START Treaty, each Party undertakes not to:
(a) produce, flight-test, or deploy an ICBM or SLBM with a number of reentry vehicles greater than the number of warheads attributed to it under this Treaty; and
(b) increase the number of warheads attributed to an ICBM or SLBM that has had the number of warheads attributed to it reduced in accordance with the provisions of this Article.

ARTICLE IV

1. For the purposes of this Treaty, the number of warheads attributed to each deployed heavy bomber shall be equal to the number of nuclear weapons for which any heavy bomber of the same type or variant of a type is actually equipped, with the exception of heavy bombers reoriented to a conventional role as provided for in paragraph 7 of this Article. Each nuclear weapon for which a heavy bomber is actually equipped shall count as one warhead toward the limitations provided for in Article I of this Treaty. For the purpose of such counting, nuclear weapons include long-range nuclear air-launched cruise missiles (ALCMs), nuclear air-to-surface missiles with a range of less than 600 kilometers, and nuclear bombs.
2. For the purposes of this Treaty, the number of nuclear weapons for which a heavy bomber is actually equipped shall be the number specified for heavy bombers of that type and variant of a type in the Memorandum of Understanding on Warhead Attribution and Heavy Bomber Data Relating to the Treaty Between the United States of America and the Russian Federation on Further Reduction and Limitation of Strategic Offensive Arms,

hereinafter referred to as the Memorandum on Attribution.

3. Each Party undertakes not to equip any heavy bomber with a greater number of nuclear weapons than the number specified for heavy bombers of that type or variant of a type in the Memorandum on Attribution.
4. No later than 180 days after entry into force of this Treaty, each Party shall exhibit one heavy bomber of each type and variant of a type specified in the Memorandum on Attribution.

   The purpose of the exhibition shall be to demonstrate to the other Party the number of nuclear weapons for which a heavy bomber of a given type or variant of a type is actually equipped.
5. If either Party intends to change the number of nuclear weapons specified in the Memorandum on Attribution, for which a heavy bomber of a type or variant of a type is actually equipped, it shall provide a 90-day advance notification of such intention to the other Party. Ninety days after providing such a notification, or at a later date agreed by the Parties, the Party changing the number of nuclear weapons for which a heavy bomber is actually equipped shall exhibit one heavy bomber of each such type or variant of a type. The purpose of the exhibition shall be to demonstrate to the other Party the revised number of nuclear weapons for which heavy bombers of the specified type or variant of a type are actually equipped. The number of nuclear weapons attributed to the specified type and variant of a type of heavy bomber shall change on the ninetieth day after the notification of such intent. On that day, the Party changing the number of nuclear weapons for which a heavy bomber is actually equipped shall provide to the other Party a notification of each change in data according to categories of data contained in the Memorandum on Attribution.
6. The exhibitions and inspections conducted pursuant to paragraphs 4 and 5 of this Article shall be carried out in accordance with the procedures provided for in the Protocol on Exhibitions and Inspections of Heavy Bombers Relating to the Treaty Between the United States of America and the Russian Federation on Further Reduction and Limitation of Strategic Offensive Arms, hereinafter referred to as the Protocol on Exhibitions and Inspections.
7. Each Party shall have the right to reorient to a conventional role heavy bombers equipped for nuclear armaments other than long-range nuclear ALCMs. For the purposes of this Treaty, heavy bombers reoriented to a conventional role are those heavy bombers specified by a Party from among its heavy bombers equipped for nuclear armaments other than long-range nuclear ALCMs that have never been accountable under the START Treaty as heavy bombers equipped for long-range nuclear ALCMs. The reorienting Party shall provide to the other Party a notification of its intent to reorient a heavy bomber to a conventional role no less than 90 days in advance of such reorientation. No conversion procedures shall be required for such a heavy bomber to be specified as a heavy bomber reoriented to a conventional role.
8. Heavy bombers reoriented to a conventional role shall be subject to the following requirements:
   (a) the number of such heavy bombers shall not exceed 100 at any one time;
   (b) such heavy bombers shall be based separately from heavy bombers with nuclear roles;
   (c) such heavy bombers shall be used only for non-nuclear missions. Such heavy bombers shall not be used in exercises for nuclear missions, and their aircrews shall not train or exercise for such missions; and
   (d) heavy bombers reoriented to a conventional role shall have differences from other heavy bombers of that type or variant of a type that are observable by national technical means of verification and visible during inspection.
9. Each Party shall have the right to return to a nuclear role heavy bombers that have been reoriented in accordance with paragraph 7 of this Article to a conventional role. The Party carrying out such action shall provide to the other Party through diplomatic channels notification of its intent to return a heavy bomber to a nuclear role no less than 90 days in advance of taking such action. Such a heavy bomber returned to a nuclear role shall not subsequently be reoriented to a conventional role.

   Heavy bombers reoriented to a conventional role that are subsequently returned to a nuclear role shall have differences observable by national technical means of verification and visible during inspection from other heavy bombers of that type and variant of a type that have not been reoriented to a conventional role, as well as from heavy bombers of that type and variant of a type that are still reoriented to a conventional role.

10. Each Party shall locate storage areas for heavy bomber nuclear armaments no less than 100 kilometers from any air base where heavy bombers reoriented to a conventional role are based.
11. Except as otherwise provided for in this Treaty, heavy bombers reoriented to a conventional role shall remain subject to the provisions of the START Treaty, including the inspection provisions.
12. If not all heavy bombers of a given type or variant of a type are reoriented to a conventional role, one heavy bomber of each type or variant of a type of heavy bomber reoriented to a conventional role shall be exhibited in the open for the purpose of demonstrating to the other Party the differences referred to in subparagraph 8(d) of this Article. Such differences shall be subject to inspection by the other Party.
13. If not all heavy bombers of a given type or variant of a type reoriented to a conventional role are returned to a nuclear role, one heavy bomber of each type and variant of a type of heavy bomber returned to a nuclear role shall be exhibited in the open for the purpose of demonstrating to the other Party the differences referred to in paragraph 9 of this Article. Such differences shall be subject to inspection by the other Party.
14. The exhibitions and inspections provided for in paragraphs 12 and 13 of this Article shall be carried out in accordance with the procedures provided for in the Protocol on Exhibitions and Inspections.

ARTICLE V

1. Except as provided for in this Treaty, the provisions of the START Treaty, including the verification provisions, shall be used for implementation of this Treaty.
2. To promote the objectives and implementation of the provisions of this Treaty, the Parties hereby establish the Bilateral Implementation Commission. The Parties agree that, if either Party so requests, they shall meet within the framework of the Bilateral Implementation Commission to:
   (a) resolve questions relating to compliance with the obligations assumed; and
   (b) agree upon such additional measures as may be necessary to improve the viability and effectiveness of this Treaty.

ARTICLE VI

1. This Treaty, including its Memorandum on Attribution, Elimination and Conversion Protocol, and Protocol on Exhibitions and Inspections, all of which are integral parts thereof, shall be subject to ratification in accordance with the constitutional procedures of each Party. This Treaty shall enter into force on the date of the exchange of instruments of ratification, but not prior to the entry into force of the START Treaty.
2. The provisions of paragraph 8 of Article II of this Treaty shall be applied provisionally by the Parties from the date of its signature.
3. This Treaty shall remain in force so long as the START Treaty remains in force.
4. Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests. It shall give notice of its decision to the other Party six months prior to withdrawal from this Treaty. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests.

ARTICLE VII

Each Party may propose amendments to this Treaty. Agreed amendments shall enter into force in accordance with the procedures governing entry into force of this Treaty.

ARTICLE VIII

This Treaty shall be registered pursuant to Article 102 of the Charter of the United Nations.

DONE at Moscow on January 3, 1993, in two copies, each in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES AMERICA — FOR THE RUSSIAN FEDERATION:

George W. Bush — *Boris Yeltsin*

Strategic Offensive Reductions Treaty (2002)

The United States of America and the Russian Federation, hereinafter referred to as the Parties,

Embarking upon the path of new relations for a new century and committed to the goal of strengthening their relationship through cooperation and friendship,

Believing that new global challenges and threats require the building of a qualitatively new foundation for strategic relations between the Parties,

Desiring to establish a genuine partnership based on the principles of mutual security, cooperation, trust, openness, and predictability,

Committed to implementing significant reductions in strategic offensive arms,

Proceeding from the Joint Statements by the President of the United States of America and the President of the Russian Federation on Strategic Issues of July 22, 2001 in Genoa and on a New Relationship between the United States and Russia of November 13, 2001 in Washington,

Mindful of their obligations under the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Reduction and Limitation of Strategic Offensive Arms of July 31, 1991, hereinafter referred to as the START Treaty,

Mindful of their obligations under Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons of July 1, 1968, and

Convinced that this Treaty will help to establish more favorable conditions for actively promoting security and cooperation, and enhancing international stability,

Have agreed as follows:

ARTICLE I

Each Party shall reduce and limit strategic nuclear warheads, as stated by the President of the United States of America on November 13, 2001 and as stated by the President of the Russian Federation on November 13, 2001 and December 13, 2001 respectively, so that by December 31, 2012 the aggregate number of such warheads does not exceed 1700-2200 for each Party. Each Party shall determine for itself the composition and structure of its strategic offensive arms, based on the established aggregate limit for the number of such warheads.

ARTICLE II

The Parties agree that the START Treaty remains in force in accordance with its terms.

ARTICLE III

For purposes of implementing this Treaty, the Parties shall hold meetings at least twice a year of a Bilateral Implementation Commission.

ARTICLE IV

1. This Treaty shall be subject to ratification in accordance with the constitutional procedures of each Party. This Treaty shall enter into force on the date of the exchange of instruments of ratification.
2. This Treaty shall remain in force until December 31, 2012 and may be extended by agreement of the Parties or superseded earlier by a subsequent agreement.
3. Each Party, in exercising its national sovereignty, may withdraw from this Treaty upon three months written notice to the other Party.

ARTICLE V

This Treaty shall be registered pursuant to Article 102 of the Charter of the United Nations.

Done at Moscow on May 24, 2002, in two copies, each in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES OF AMERICA: — FOR THE RUSSIAN FEDERATION:

George W. Bush — *Vladimir Putin*

Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (Treaty of Tlatelolco)*

Opened for Signature: 14 February 1967.
Entered into Force: 22 April 1968.

PREAMBLE

In the name of their peoples and faithfully interpreting their desires and aspirations, the Governments of the States which sign the Treaty for the Prohibition of Nuclear Weapons in Latin America,

Desiring to contribute, so far as lies in their power, towards ending the armaments race, especially in the field of nuclear weapons, and towards strengthening a world at peace, based on the sovereign equality of States, mutual respect and good neighbourliness,

Recalling that the United Nations General Assembly, in its resolution 808 (IX), adopted unanimously as one of the three points of a coordinated programme of disarmament "the total prohibition of the use and manufacture of nuclear weapons and weapons of mass destruction of every type",

Recalling that militarily denuclearized zones are not an end in themselves but rather a means for achieving general and complete disarmament at a later stage,

Recalling United Nations General Assembly resolution 1911 (XVIII), which established that the measures that should be agreed upon for the denuclearization of Latin America should be taken ain the light of the principles of the Charter of the United Nations and of regional agreements",

Recalling United Nations General Assembly resolution 2028 (XX), which established the principle of an acceptable balance of mutual responsibilities and duties for the nuclear and non-nuclear powers, and

Recalling that the Charter of the Organization of American States proclaims that it is an essential purpose of the Organization to strengthen the peace and security of the hemisphere,

Convinced:

That the incalculable destructive power of nuclear weapons has made it imperative that the legal prohibition of war should be strictly observed in practice if the survival of civilization and of mankind itself is to be assured,

That nuclear weapons, whose terrible effects are suffered, indiscriminately and inexorably, by military forces and civilian population alike, constitute, through the persistence of the radioactivity they release, an attack on the integrity of the human species and ultimately may even render the whole earth uninhabitable,

That general and complete disarmament under effective international control is a vital matter which all the peoples of the world equally demand,

That the proliferation of nuclear weapons, which seems inevitable unless States, in the exercise of their sovereign rights, impose restrictions on themselves in order to prevent it, would make any agreement on disarmament enormously difficult and would increase the danger of the outbreak of a nuclear conflagration,

That the establishment of militarily denuclearized zones is closely linked with the maintenance of peace and security in the respective regions,

That the military denuclearization of vast geographical zones, adopted by the Sovereign decision of the States comprised therein, will exercise a beneficial influence on other regions where similar conditions exist,

That the privileged situation of the signatory States, whose territories are wholly free from nuclear weapons, imposes upon them the inescapable duty of preserving that situation both in their own interests and for the good of mankind,

That the existence of nuclear weapons in any country of Latin America would make it a target for possible nuclear attacks and would inevitably set off,

throughout the region a ruinous race in nuclear weapons which would involve the unjustifiable diversion, for warlike purposes, of the limited resources required for economic and social development,

That the foregoing reasons, together with the traditional peace-loving outlook of Latin America, give rise to an inescapable necessity that nuclear energy should be used in that region exclusively for peaceful purposes, and that the Latin American countries should use their right to the greatest and most equitable possible access to this new source of energy in order to expedite the economic and social development of their peoples,

Convinced finally:

That the military denuclearization of Latin America - being understood to mean the undertaking entered into internationally in this Treaty to keep their territories forever free from nuclear weapons - will constitute a measure which will spare their peoples from the squandering of their limited resources on nuclear armaments and will protect them against possible nuclear attacks on their territories, and will also constitute a significant contribution towards preventing the proliferation of nuclear weapons and a powerful factor for general and complete disarmament, and

That Latin America, faithful to its tradition of universality, must not only endeavour to banish from its homelands the scourge of a nuclear war, but must also strive to promote the well-being and advancement of its peoples, at the same time cooperating in the fulfilment of the ideals of mankind, that is to say, in the consolidation of a permanent peace based on equal rights, economic fairness and social justice for all, in accordance with the principles and purposes set forth in the Charter of the United Nations and in the Charter of the Organization of American States,

Have agreed as follows:

OBLIGATIONS

Article I

1. The Contracting Parties hereby undertake to use exclusively for peaceful purposes the nuclear material and facilities which are under their jurisdiction, and to prohibit and prevent in their respective territories:
   (a) The testing, use, manufacture, production or acquisition by any means whatsoever of any nuclear weapons, by the Parties themselves, directly or indirectly, on behalf of anyone else or in any other way, and
   (b) The receipt, storage, installation, deployment and any form of possession of any nuclear weapons, directly or indirectly, by the Parties themselves, by anyone on their behalf or in any other way.
2. The Contracting Parties also undertake to refrain from engaging in, encouraging or authorizing, directly or indirectly, or in any way participating in the testing, use, manufacture, production, possession or control of any nuclear weapon.

DEFINITION OF THE CONTRACTING PARTIES

Article 2

For the purposes of this Treaty, the Contracting Parties are those for whom the Treaty is in force.

DEFINITION OF TERRITORY

Article 3

For the purposes of this Treaty, the term “territory” shall include the territorial sea, air space and any other space over which the State exercises sovereignty in accordance with its own legislation.

ZONE OF APPLICATION

Article 4

1. The zone of application of this Treaty is the whole of the territories for which the Treaty is in force.
2. Upon fulfilment of the requirements of article 28, paragraph 1, the zone of application of this Treaty shall also be that which is situated in the western hemisphere within the following limits (except the continental part of the territory of the United States of America and its territorial waters): starting at a point located at 35∞ north latitude, 75∞ west longitude; from this point directly southward to a point at 30∞ north latitude, 75∞ west longitude; from there, directly eastward to a point at 30∞ north latitude, 50∞ west longitude; from there, along a loxodromic line to a point at 5∞ north latitude, 20∞ west longitude; from there, directly southward to a point at 60∞ south latitude, 20∞ west longitude; from there, directly westward to a point at 60∞ south latitude, 115∞ west longitude; from there, directly northward to a point at 0 latitude, 115∞ west longitude; from there, along a loxodromic line to a point at 35∞ north latitude, 150∞ west longitude; from there, directly eastward to a point at 35∞ north latitude, 75∞ west longitude.

DEFINITION OF NUCLEAR WEAPONS

Article 5

For the purposes of this Treaty, a nuclear weapon is any device which is capable of releasing nuclear energy in an uncontrolled manner and which has a group of characteristics that are appropriate for use for warlike purposes. An instrument that may be used for the transport or propulsion of the device is not included in this definition if it is separable from the device and not an indivisible part thereof.

MEETING OF SIGNATORIES

Article 6

At the request of any of the signatory States or if the Agency established by article 7 should so decide, a meeting of all the signatories may be convoked to consider in common questions which may affect the very essence of this instrument, including possible amendments to it. In either case, the meeting will be convoked by the General Secretary.

ORGANIZATION

Article 7

1. In order to ensure compliance with the obligations of this Treaty, the Contracting

Parties hereby establish an international organization to be known as the Agency for the Prohibition of Nuclear Weapons in Latin America, hereinafter referred to as "the Agency". Only the Contracting Parties shall be affected by its decisions.

2. The Agency shall be responsible for the holding of periodic or extraordinary consultations among Member States on matters relating to the purposes, measures and procedures set forth in this Treaty and to the supervision of compliance with the obligations arising therefrom.
3. The Contracting Parties agree to extend to the Agency full and prompt cooperation in accordance with the provisions of this Treaty, of any agreements they may conclude with the Agency and of any agreements the Agency may conclude with any other international organization or body.
4. The headquarters of the Agency shall be in Mexico City.

ORGANS

Article 8

1. There are hereby established as principal organs of the Agency a General Conference, a Council and a Secretariat.
2. Such subsidiary organs as are considered necessary by the General Conference may be established within the purview of this Treaty.

THE GENERAL CONFERENCE

Article 9

1. The General Conference, the supreme organ of the Agency, shall be composed of all the Contracting Parties; it shall hold regular sessions every two years, and may also hold special sessions whenever this Treaty so provides or, in the opinion of the Council, the circumstances so require.
2. The General Conference:
(a) May consider and decide on any matters or questions covered by this Treaty, within the limits thereof, including those referring to powers and functions of any organ provided for in this Treaty;
(b) Shall establish procedures for the control system to ensure observance of this Treaty in accordance with its provisions;
(c) Shall elect the Members of the Council and the General Secretary;
(d) May remove the General Secretary from office if the proper functioning of the Agency so requires;
(e) Shall receive and consider the biennial and special reports submitted by the Council and the General Secretary;
(f) Shall initiate and consider studies designed to facilitate the optimum fulfilment of the aims of this Treaty, without prejudice to the power of the General Secretary independently to carry out similar studies for submission to and consideration by the Conference;
(g) Shall be the organ competent to authorize the conclusion of agreements with Governments and other international organizations and bodies.
3. The General Conference shall adopt the Agency's budget and fix the scale of financial contributions to be paid by Member States, taking into account the systems and criteria used for the same purpose by the United Nations.
4. The General Conference shall elect its officers for each session and may establish such subsidiary organs as it deems necessary for the performance of its functions.
5. Each Member of the Agency shall have one vote. The decisions of the General Conference shall be taken by a two-thirds majority of the Members present and voting in the case of matters relating to the control system and measures referred to in article 20, the admission of new Members, the election or removal of the General Secretary, adoption of the budget and matters related thereto. Decisions on other matters, as well as procedural questions and also determination of which questions must be decided by a two-thirds majority, shall be taken by a simple majority of the Members present and voting.
6. The General Conference shall adopt its own rules of procedure.

THE COUNCIL

Article 10

1. The Council shall be composed of five Members of the Agency elected by the General Conference from among the Contracting Parties, due account being taken of equitable geographic distribution.

2. The Members of the Council shall be elected for a term of four years. However, in the first election three will be elected for two years. Outgoing Members may not be re-elected for the following period unless the limited number of States for which the Treaty is in force so requires.
3. Each Member of the Council shall have one representative.
4. The Council shall be so organized as to be able to function continuously.
5. In addition to the functions conferred upon it by this Treaty and to those which may be assigned to it by the General Conference, the Council shall, through the General Secretary, ensure the proper operation of the control system in accordance with the provisions of this Treaty and with the decisions adopted by the General Conference.
6. The Council shall submit an annual report on its work to the General Conference as well as such special reports as it deems necessary or which the General Conference requests of it.
7. The Council shall elect its officers for each session.
8. The decisions of the Council shall be taken by a simple majority of its Members present and voting.
9. The Council shall adopt its own rules of procedure.

THE SECRETARIAT

Article 11

1. The Secretariat shall consist of a General Secretary, who shall be the chief administrative officer of the Agency, and of such staff as the Agency may require. The term of office of the General Secretary shall be four years and he may be re-elected for a single additional term. The General Secretary may not be a national of the country in which the Agency has its headquarters. In case the office of General Secretary becomes vacant, a new election shall be held to fill the office for the remainder of the term.
2. The staff of the Secretariat shall be appointed by the General Secretary, in accordance with rules laid down by the General Conference.
3. In addition to the functions conferred upon him by this Treaty and to those which may be assigned to him by the General Conference, the General Secretary shall ensure, as provided by article 10, paragraph 5, the proper operation of the control system established by this Treaty, in accordance with the provisions of the Treaty and the decisions taken by the General Conference.
4. The General Secretary shall act in that capacity in all meetings of the General Conference and of the Council and shall make an annual report to both bodies on the work of the Agency and any special reports requested by the General Conference or the Council or which the General Secretary may deem desirable.
5. The General Secretary shall establish the procedures for distributing to all Contracting Parties information received by the Agency from governmental sources and such information from non-governmental sources as may be of interest to the Agency.
6. In the performance of their duties the General Secretary and the staff shall not seek or receive instructions from any Government or from any other authority external to the Agency and shall refrain from any action which might reflect on their position as international officials responsible only to the Agency; subject to their responsibility to the Agency, they shall not disclose any industrial secrets or other confidential information coming to their knowledge by reason of their official duties in the Agency.
7. Each of the Contracting Parties undertakes to respect the exclusively international character of the responsibilities of the General Secretary and the staff and not to seek to influence them in the discharge of their responsibilities.

CONTROL SYSTEM

Article 12

1. For the purpose of verifying compliance with the obligations entered into by the Contracting Parties in accordance with article 1, a control system shall be established which shall be put into effect in accordance with the provisions of articles 13-18 of this Treaty.
2. The control system shall be used in particular for the purpose of verifying:
(a) That devices, services and facilities intended for peaceful uses of nuclear energy are not used in the testing or manufacture of nuclear weapons;

(b) That none of the activities prohibited in article 1 of this Treaty are carried out in the territory of the Contracting Parties with nuclear materials or weapons introduced from abroad; and
(c) That explosions for peaceful purposes are compatible with article 18 of this Treaty.

IAEA SAFEGUARDS

Article 13

Each Contracting Party shall negotiate multilateral or bilateral agreements with the International Atomic Energy Agency for the application of its safeguards to its nuclear activities. Each Contracting Party shall initiate negotiations within a period of 180 days after the date of the deposit of its instrument of ratification of this Treaty. These agreements shall enter into force, for each Party, not later than eighteen months after the date of the initiation of such negotiations except in case of unforeseen circumstances or force majeure.

REPORTS OF THE PARTIES

Article 14

1. The Contracting Parties shall submit to the Agency and to the International Atomic Energy Agency, for their information, semi-annual reports stating that no activity prohibited under this Treaty has occurred in their respective territories.
2. The Contracting Parties shall simultaneously transmit to the Agency a copy of any report they may submit to the International Atomic Energy Agency which relates to matters that are the subject of this Treaty and to the application of safeguards.
3. The Contracting Parties shall also transmit to the Organization of American States, for its information, any reports that may be of interest to it, in accordance with the obligations established by the Inter-American System.

SPECIAL REPORTS REQUESTED BY THE GENERAL SECRETARY

Article 15

1. With the authorization of the Council, the General Secretary may request any of the Contracting Parties to provide the Agency with complementary or supplementary information regarding any event or circumstance connected with compliance with this Treaty, explaining his reasons. The Contracting Parties undertake to cooperate promptly and fully with the General Secretary.
2. The General Secretary shall inform the Council and the Contracting Parties forthwith of such requests and of the respective replies.

SPECIAL INSPECTIONS

Article 16

1. The International Atomic Energy Agency and the Council established by this Treaty have the power of carrying out special inspections in the following cases:
(a) In the case of the International Atomic Energy Agency, in accordance with the agreements referred to in article 13 of this Treaty;
(b) in the case of the Council:
When so requested, the reasons for the request being stated, by any Party which suspects that some activity prohibited by this Treaty has been carried out or is about to be carried out, either in the territory of any other Party or in any other place on such latter Party's behalf, the Council shall immediately arrange for such an inspection in accordance with article 10, paragraph 5;
When requested by any Party which has been suspected of or charged with having violated this shall immediately arrange for the special inspection requested in accordance with article 10, paragraph 5.
The above requests will be made to the Council through the General Secretary.
2. The costs and expenses of any special inspection carried out under paragraph 1, subparagraph (b), sections (i) and (ii) of this article shall be borne by the requesting Party or Parties, except where the Council concludes on the basis of the report on the special inspection that, in view of the circumstances existing in the case, such costs and expenses should be borne by the Agency.
3. The General Conference shall formulate the procedures for the organization and execution of the special inspections carried out in accordance with paragraph 1, subparagraph (b), sections (i) and (ii) of this article.

4. The Contracting Parties undertake to grant the inspectors carrying out such special inspections full and free access to all places and all information which may be necessary for the performance of their duties and which are directly and intimately connected with the suspicion of violation of this Treaty. If so requested by the authorities of the Contracting Party in whose territory the inspection is carried out, the inspectors designated by the General Conference shall be accompanied by representatives of said authorities, provided that this does not in any way delay or hinder the work of the inspectors.
5. The Council shall immediately transmit to all the Parties, through the General Secretary, a copy of any report resulting from special inspections.
6. Similarly, the Council shall send through the General Secretary to the Secretary-General of the United Nations, for transmission to the United Nations Security Council and General Assembly, and to the Council of the Organization of American States, for its information, a copy of any report resulting from any special inspection carried out in accordance with paragraph 1, subparagraph (b), sections (i) and (ii) of this article.
7. The Council may decide, or any Contracting Party may request, the convening of a special session of the General Conference for the purpose of considering the reports resulting from any special inspection. In such a case, the General Secretary shall take immediate steps to convene the special session requested.
8. The General Conference, convened in special session under this article, may make recommendations to the Contracting Parties and submit reports to the Secretary-General of the United Nations to be transmitted to the United Nations Security Council and the General Assembly.

USE OF NUCLEAR ENERGY FOR PEACEFUL PURPOSES

Article 17

Nothing in the provisions of this Treaty shall prejudice the rights of the Contracting Parties, in conformity with this Treaty, to use nuclear energy for peaceful purposes, in particular for their economic development and social progress.

EXPLOSIONS FOR PEACEFUL PURPOSES

Article 18

1. The Contracting Parties may carry out explosions of nuclear devices for peaceful purposes - including explosions which involve devices similar to those used in nuclear weapons - or collaborate with third parties for the same purpose, provided that they do so in accordance with the provisions of this article and the other articles of the Treaty, particularly articles I and 5.
2. Contracting Parties intending to carry out, or to cooperate in carrying out, such an explosion shall notify the Agency and the International Atomic Energy Agency, as far in advance as the circumstances require, of the date of the explosion and shall at the same time provide the following information:
   (a) The nature of the nuclear device and the source from which it was obtained;
   (b) The place and purpose of the planned explosion;
   (c) The procedures which will be followed in order to comply with paragraph 3 of this article;
   (d) The expected force of the device; and
   (e) The fullest possible information on any possible radioactive fall-out that may result from the explosion or explosions, and measures which will be taken to avoid danger to the population, flora, fauna and territories of any other Party or Parties.
3. The General Secretary and the technical personnel designated by the Council and the International Atomic Energy Agency may observe all the preparations, including the explosion of the device, and shall have unrestricted access to any area in the vicinity of the site of the explosion in order to ascertain whether the device and the procedures followed during the explosion are in conformity with the information supplied under paragraph 2 of this article and the other provisions of this Treaty.
4. The Contracting Parties may accept the collaboration of third parties for the purposes set forth in paragraph 1 of the present article, in accordance with paragraphs 2 and 3 thereof.

RELATIONS WITH OTHER INTERNATIONAL ORGANIZATIONS

Article 1 9

1. The Agency may conclude such agreements with the International Atomic Energy Agency as are authorized by the General Conference and as it considers likely to facilitate the efficient operation of the control system established by this Treaty.
2. The Agency may also enter into relations with any international Organization or body, especially any which may be established in the future to supervise disarmament or measures for the control of armaments in any part of the world.
3. The Contracting Parties may, if they see fit, request the advice of the Inter-American Nuclear Energy Commission on all technical matters connected with the application of this Treaty with which the Commission is competent to deal under its Statute.

MEASURES IN THE EVENT OF VIOLATION OF THE TREATY

Article 20

1. The General Conference shall take note of all cases in which, in its opinion, any Contracting Party is not complying fully with its obligations under this Treaty and shall draw the matter to the attention of the Party concerned, making such recommendations as it deems appropriate.
2. If, in its opinion, such non-compliance constitutes a violation of this Treaty which might endanger peace and security, the General Conference shall report thereon simultaneously to the United Nations Security Council and the General Assembly through the Secretary-General of the United Nations, and to the Council of the Organization of American States. The General Conference shall likewise report to the International Atomic Energy Agency for such purposes as are relevant in accordance with its Statute.

UNITED NATIONS AND ORGANIZATION OF AMERICAN STATES

Article 21
None of the provisions of this Treaty shall be construed as impairing the rights and obligations of the Parties under the Charter of the United Nations or, in the case of States Members of the Organization of American States, under existing regional treaties.

PRIVILEGES AND IMMUNITIES

Article 22

1. The Agency shall enjoy in the territory of each of the Contracting Parties such legal capacity. and such privileges and immunities as may be necessary for the exercise of its functions and the fulfilment of its purposes.
2. Representatives of the Contracting Parties accredited to the Agency and officials of the Agency shall similarly enjoy such privileges and immunities as are necessary for the performance of their functions.
3. The Agency may conclude agreements with the Contracting Parties with a view to determining the details of the application of paragraphs 1 and 2 of this article.

NOTIFICATION OF OTHER AGREEMENTS

Article 23
Once this Treaty has entered into force, the Secretariat shall be notified immediately of any international agreement concluded by any of the Contracting Parties on matters with which this Treaty is concerned; the Secretariat shall register it and notify the other Contracting Parties.

SETTLEMENT OF DISPUTES

Article 24
Unless the Parties concerned agree on another mode of peaceful settlement, any question or dispute concerning the interpretation or application of this Treaty which is not settled shall be referred to the International Court of Justice with the prior consent of the Parties to the controversy

SIGNATURE

Article 25

1. This Treaty shall be open indefinitely for signature by:
   (a) All the Latin American Republics; and
   (b) All other sovereign States situated in their entirety south of latitude 35 north in the western hemisphere; and, except as provided

in paragraph 2 of this article, all such States which become sovereign, when they have been admitted by the General Conference.

2. The General Conference shall not take any decision regarding the admission of a political entity part or all of whose territory is the subject, prior to the date when this Treaty is opened for signature, of a dispute or claim between an extra-continental country and one or more Latin American States, so long as the dispute has not been settled by peaceful means.

RATIFICATION AND DEPOSIT

Article 26

1. This Treaty shall be subject to ratification by signatory States in accordance with their respective constitutional procedures.
2. This Treaty and the instruments of ratification shall be deposited with the Government of the Mexican United States, which is hereby designated the Depositary Government.
3. The Depositary Government shall send certified copies of this Treaty to the Governments of signatory States and shall notify them of the deposit of each instrument of ratification.

RESERVATIONS

Article 27
This Treaty shall not be subject to reservations.

ENTRY INTO FORCE

Article 28

1. Subject to the provisions of paragraph 2 of this article, this Treaty shall enter into force among the States that have ratified it as soon as the following requirements have been met:
(a) Deposit of the instruments of ratification of this Treaty with the Depositary Government by the Governments of the States mentioned in article 25 which are in existence on the date when this Treaty is opened for signature and which are not affected by the provisions of article 25, paragraph 2;
(b) Signature and ratification of Additional Protocol I annexed to this Treaty by all extra-continental or continental States having de jure or de facto international responsibility for territories situated in the zone of application of the Treaty;
(c) Signature and ratification of the Additional Protocol 11 annexed to this Treaty by all powers possessing nuclear weapons;
(d) Conclusion of bilateral or multilateral agreements on the application of the Safeguards System of the International Atomic Energy Agency in accordance with article 13 of this Treaty.
2. All signatory States shall have the imprescriptible right to waive, wholly or in part, the requirements laid down in the preceding paragraph. They may do so by means of a declaration which shall be annexed to their respective instrument of ratification and which may be formulated at the time of deposit of the instrument or subsequently. For those States which exercise this right, this Treaty shall enter into force upon deposit of the declaration, or as soon as those requirements have been met which have not been expressly waived.
3. As soon as this Treaty has entered into force in accordance with the provisions of paragraph 2 for eleven States, the Depositary Government shall convene a preliminary meeting of those States in order that the Agency may be set up and commence its work.
4. After the entry into force of this Treaty for all the countries of the zone, the rise of a new power possessing nuclear weapons shall have the effect of suspending the execution of this Treaty for those countries which have ratified it without waiving requirements of paragraph 1, sub-paragraph (c) of this article, and which request such suspension; the Treaty shall remain suspended until the new power, on its own initiative or upon request by the General Conference, ratifies the annexed Additional Protocol n.

AMENDMENTS

Article 29

1. Any Contracting Party may propose amendments to this Treaty and shall submit its proposals to the Council through the General Secretary, who shall transmit them to all the other Contracting Parties and, in addition, to all other signatories in accordance with article 6. The Council, through the General Secretary, shall immediately following

the meeting of signatories convene a special session of the General Conference to examine the proposals made, for the adoption of which a two-thirds majority of the Contracting Parties present and voting shall be required.

2. Amendments adopted shall enter into force as soon as the requirements set forth in article 28 of this Treaty have been complied with.

DURATION AND DENUNCIATION

Article 30

1. This Treaty shall be of a permanent nature and shall remain in force indefinitely, but any Party may denounce it by notifying the General Secretary of the Agency if, in the opinion of the denouncing State, there have arisen or may arise circumstances connected with the content of this Treaty or of the annexed Additional Protocols I and II which affect its supreme interests or the peace and security of one or more Contracting Parties.
2. The denunciation shall take effect three months after the delivery to the General Secretary of the Agency of the notification by the Government of the signatory State concerned. The General Secretary shall immediately communicate such notification to the other Contracting Parties and to the Secretary-General of the United Nations for the information of the United Nations Security Council and the General Assembly. He shall also communicate it to the Secretary-General of the Organization of American States.

AUTHENTIC TEXTS AND REGISTRATION

Article 31

This Treaty, of which the Spanish, Chinese, English, French, Portuguese and Russian texts are equally authentic, shall be registered by the Depositary Government in accordance with article 102 of the United Nations Charter. The Depositary Government shall notify the Secretary-General of the United Nations of the signatures, ratifications and amendments relating to this Treaty and shall communicate them to the Secretary-General of the Organization of American States for its information.

Transitional Article

Denunciation of the declaration referred to in article 28, paragraph 2, shall be subject to the same procedures as the denunciation of this Treaty, except that it will take effect on the date of delivery of the respective notification.

IN WITNESS WHEREOF the undersigned Plenipotentiaries, having deposited their full powers, found in good and due form, sign this Treaty on behalf of their respective Governments.

Done at Mexico, Distrito Federal, on the Fourteenth day of February, one thousand nine hundred and sixty-seven.

ADDITIONAL PROTOCOL I

The undersigned Plenipotentiaries, furnished with full powers by their respective Governments,

Convinced that the Treaty for the Prohibition of Nuclear Weapons in Latin America, negotiated and signed in accordance with the recommendations of the General Assembly of the United Nations in Resolution 1911 (XVIII) of 27 November 1963, represents an important step towards ensuring the non-proliferation of nuclear weapons,

Aware that the non-proliferation of nuclear weapons is not an end in itself but, rather, a means of achieving general and complete disarmament at a later stage, and

Desiring to contribute, so far as lies in their power, towards ending the armaments race, especially in the field of nuclear weapons, and towards strengthening a world peace, based on mutual respect and sovereign equality of States,

Have agreed as follows:

ARTICLE I

To undertake to apply the statute of denuclearization in respect of warlike purposes as defined in articles 1, 3, 5 and 13 of the Treaty for the Prohibition of Nuclear Weapons in Latin America in territories for which, de jure or de facto, they are internationally responsible and which lie within the limits of the geographical zone established in that Treaty.

ARTICLE 2

The duration of this Protocol shall be the same as that of the Treaty for the Prohibition of Nuclear Weapons in Latin America of which this Protocol is an annex, and the provisions regarding ratification and denunciation contained in the Treaty shall be applicable to it.

ARTICLE 3

This Protocol shall enter into force, for the States which have ratified it, on the date of the deposit of their respective instruments of ratification.

IN WITNESS WHEREOF the undersigned Plenipotentiaries, having deposited their full powers, found in good and due form, sign this Protocol on behalf of their respective Governments.

ADDITIONAL PROTOCOL II

The undersigned Plenipotentiaries, furnished with full powers by their respective Governments,

Convinced that the Treaty for the Prohibition of Nuclear Weapons in Latin America, negotiated and signed in accordance with the recommendations of the General Assembly of the United Nations in Resolution 1911 (XVIII) of 27 November 1963, represents an important step towards ensuring the non-proliferation of nuclear weapons, Aware that the non-proliferation of nuclear weapons is not an end in itself but, rather, a means of achieving general and complete disarmament at a later stage, and Desiring to contribute, so far as lies in their power, towards ending the armaments race, especially in the field of nuclear weapons, and towards promoting and strengthening a world at peace, based on mutual respect and sovereign equality of States,

Have agreed as follows:

ARTICLE I

The statute of denuclearization of Latin America in respect of warlike purposes, as defined, delimited and set forth in the Treaty for the Prohibition of Nuclear Weapons in Latin America of which this instrument is an annex, shall be fully respected by the Parties to this Protocol in all its express aims and provisions.

ARTICLE 2

The Governments represented by the undersigned Plenipotentiaries undertake, therefore, not to contribute in any way to the performance of acts involving a violation of the obligations of article 1 of the Treaty in the territories to which the Treaty applies in accordance with article 4 thereof.

ARTICLE 3

The Governments represented by the undersigned Plenipotentiaries also undertake not to use or threaten to use nuclear weapons against the Contracting Parties of the Treaty for the Prohibition of Nuclear Weapons in Latin America.

ARTICLE 4

The duration of this Protocol shall be the same as that of the Treaty for the Prohibition of Nuclear Weapons in Latin America of which this Protocol is an annex, and the definitions of territory and nuclear weapons set forth in articles 3 and 5 of the Treaty shall be applicable to this Protocol, as well as the provisions regarding ratification, reservations, denunciation, authentic texts and registration contained in articles 26, 27, 30 and 31 of the Treaty.

ARTICLE 5

This Protocol shall enter into force, for the States which have ratified it, on the date of the deposit of their respective instruments of ratification.

IN WITNESS WHEREOF, the undersigned Plenipotentiaries, having deposited their full powers, found to be in good and due form, hereby sign this Additional Protocol on behalf of their respective Governments.

* On 3 July 1990, the Agency for the Prohibition of Nuclear Weapons in Latin America decided, in its resolution 267 (E-V), to add to the legal title of the Treaty the terms "and the Caribbean", in conformity with article 7 of the Treaty.

Treaty Between The United States of America and The Union of Soviet Socialist Republics on the Limitation of Underground Nuclear Weapon Tests

Signed at Moscow July 3, 1974
Ratified December 8, 1990
Entered into force December 11, 1990

The United States of America and the Union of Soviet Socialist Republics, hereinafter referred to as the Parties,

Declaring their intention to achieve at the earliest possible date the cessation of the nuclear arms race and to take effective measures toward reductions in strategic arms, nuclear disarmament, and general and complete disarmament under strict and effective international control,

Recalling the determination expressed by the Parties to the 1963 Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water in its Preamble to seek to achieve the discontinuance of all test explosions of nuclear weapons for all time, and to continue negotiations to this end, Noting that the adoption of measures for the further limitation of underground nuclear weapon tests would contribute to the achievement of these objectives and would meet the interests of strengthening peace and the further relaxation of international tension,

Reaffirming their adherence to the objectives and principles of the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water and of the Treaty on the Non-Proliferation of Nuclear Weapons,

Have agreed as follows:

ARTICLE I

1. Each Party undertakes to prohibit, to prevent, and not to carry out any underground nuclear weapon test having a yield exceeding 150 kilotons at any place under its jurisdiction or control, beginning March 31, 1976.
2. Each Party shall limit the number of its underground nuclear weapon tests to a minimum.
3. The Parties shall continue their negotiations with a view toward achieving a solution to the problem of the cessation of all underground nuclear weapon tests.

ARTICLE II

1. For the purpose of providing assurance of compliance with the provisions of this Treaty, each Party shall use national technical means of verification at its disposal in a manner consistent with the generally recognized principles of international law.
2. Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph 1 of this Article.
3. To promote the objectives and implementation of the provisions of this Treaty the Parties shall, as necessary, consult with each other, make inquiries and furnish information in response to such inquiries.

ARTICLE III

The provisions of this Treaty do not extend to underground nuclear explosions carried out by the Parties for peaceful purposes. Underground nuclear explosions for peaceful purposes shall be governed by an agreement which is to be negotiated and concluded by the Parties at the earliest possible time.

ARTICLE IV

This Treaty shall be subject to ratification in accordance with the constitutional procedures of each Party. This Treaty shall enter into force on the day of the exchange of instruments of ratification.

ARTICLE V

1. This Treaty shall remain in force for a period of five years. Unless replaced earlier by an agreement in implementation of the objectives specified in paragraph 3 of Article I of this Treaty, it shall be extended for successive five-year periods unless either Party notifies the other of its termination no later than six months prior to the expiration of the Treaty. Before the expiration of this period the Parties may, as necessary, hold consultations to consider the situation relevant to the substance of this Treaty and to introduce possible amendments to the text of the Treaty.
2. Each Party shall, in exercising its national sovereignty, have the right to withdraw from this Treaty if it decides that extraordinary events related to the subject matter of this Treaty have jeopardized its supreme interests. It shall give notice of its decision to the other Party six months prior to withdrawal from this Treaty. Such notice shall include a statement of the extraordinary events the notifying Party regards as having jeopardized its supreme interests.
3. This Treaty shall be registered pursuant to Article 102 of the Charter of the United Nations.

DONE at Moscow on July 3, 1974, in duplicate, in the English and Russian languages, both texts being equally authentic.

FOR THE UNITED STATES OF AMERICA:

RICHARD NIXON

The President of the United States of America

FOR THE UNION OF SOVIET SOCIALIST REPUBLICS:

L. BREZHNEV

General Secretary of the Central Committee of the CPSU

The Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies

FINAL DECLARATION

1. Representatives of Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Russian Federation, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States met in Wassenaar, the Netherlands, on 18 and 19 December 1995.

2. The representatives agreed to establish The Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies.

3. The representatives established initial elements of the new arrangement, to be submitted to their respective Governments for approval.

4. They also established a Preparatory Committee of the Whole to start work in January 1996.

5. The representatives agreed to locate the Secretariat of The Wassenaar Arrangement in Vienna, Austria. The first plenary meeting will take place in Vienna on 2 and 3 April 1996.

Purposes, Guidelines & Procedures, including the Initial Elements

(as amended and updated by the Plenary of December 2003)

WA Secretariat, Vienna
December 2003

INITIAL ELEMENTS

I. Purposes

As originally established in the Initial Elements adopted by the Plenary of 11-12 July 1996 and as exceptionally amended by the Plenary of 6-7 December 2001.

1. The Wassenaar Arrangement has been established in order to contribute to regional and international security and stability, by promoting transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies, thus preventing destabilising accumulations. Participating States will seek, through their national policies, to ensure that transfers of these items do not contribute to the development or enhancement of military capabilities which undermine these goals, and are not diverted to support such capabilities.

2. It will complement and reinforce, without duplication, the existing control regimes for weapons of mass destruction and their delivery systems, as well as other internationally recognised measures designed to promote transparency and greater responsibility, by focusing on the threats to international and regional peace and security which may arise from transfers of armaments and sensitive dual-use goods and technologies where the risks are judged greatest.

3. This Arrangement is also intended to enhance co-operation to prevent the acquisition of armaments and sensitive dual-use items for military end-uses, if the situation in a region or the behaviour of a state is, or becomes, a cause for serious concern to the Participating States.

4. This Arrangement will not be directed against any state or group of states and will not impede bona fide civil transactions. Nor will it interfere with the rights of states to acquire legitimate means with which to defend themselves pursuant to Article 51 of the Charter of the United Nations.

5. In line with the paragraphs above, Participating States will continue to prevent the acquisition of conventional arms and dual-use goods and technologies by terrorist groups and organisations, as well as by individual terrorists. Such efforts are an integral part of the global fight against terrorism.[1]

II. Scope

1. Participating States will meet on a regular basis to ensure that transfers of conventional arms and transfers in dual-use goods and technologies are carried out responsibly and in furtherance of international and regional peace and security.

2. To this end, Participating States will exchange, on a voluntary basis, information that will enhance transparency, will lead to discussions among all Participating States on arms transfers, as well as on sensitive dual-use goods and technologies, and will assist in developing common understandings of the risks associated with the transfer of these items. On the basis of this information they will assess the scope for co-ordinating national control policies to combat these risks. The information to be exchanged will include any matters which individual Participating States wish to bring to the attention of others, including, for those wishing to do so, notifications which go beyond those agreed upon.

3. The decision to transfer or deny transfer of any item will be the sole responsibility of each Participating State. All measures undertaken with respect to the Arrangement will be in accordance with national legislation and policies and will be implemented on the basis of national discretion.

4. In accordance with the provisions of this Arrangement, Participating States agree to notify transfers and denials. These notifications will apply to all non-participating states. However, in the light of the general and specific information exchange, the scope of these notifications, as well as their relevance for the purposes of the Arrangement, will be reviewed. Notification of a denial will not impose an obligation on other Participating States to deny similar transfers. However, a Participating State will notify, preferably within 30 days, but no later than within 60 days, all other Participating States of an approval of a licence which has been denied by another Participating State for an essentially identical transaction during the last three years.[2]

5. Participating States agree to work expeditiously on guidelines and procedures that take into account experience acquired. This work continues and will include, in particular, a continuing review of the scope of conventional arms to be covered with a view to extending information and notifications beyond the categories described in Appendix 3. Participating States agree to discuss further how to deal with any areas of overlap between the various lists.

6. Participating States agree to assess, on a regular basis, the overall functioning of this Arrangement.

7. In fulfilling the purposes of this Arrangement as defined in Section I, Participating States have, inter alia, agreed to the following guidelines, elements and procedures as a basis for decision making through the application of their own national legislation and policies:

"*Elements for Objective Analysis and Advice Concerning Potentially Destabilising Accumulations of Conventional Weapons*"—adopted by the December 1998 Plenary;

"*Statement of Understanding on Intangible Transfers of Software and Technology*"—adopted December 2001;

"*Best Practice Guidelines for Exports of Small Arms and Light Weapons (SALW)*"—adopted December 2002";

"*Elements for Export Controls of Man-Portable Air Defence Systems (MANPADS)*"—adopted December 2003;

"*Elements for Effective Legislation on Arms Brokering*"—adopted December 2003;

"*Statement of Understanding on Control of Non-Listed Dual-Use Items*"—adopted December 2003.

III. Control Lists

1. Participating States will control all items set forth in the Lists of Dual-Use Goods and Technologies and in the Munitions List (see Appendix 5)[3], with the objective of preventing unauthorised transfers or re-transfers of those items.

2. The List of Dual-Use Goods and Technologies (Dual-Use List) has two annexes: 1) sensitive items (Sensitive List) and 2) very sensitive items (Very Sensitive List).

3. The lists will be reviewed regularly to reflect technological developments and experience gained by Participating States, including in the field of dual-use goods and technologies which are critical for indigenous military capabilities. In this respect, studies shall be completed to coincide with the first revision to the lists to establish an appropriate level of transparency for pertinent items.

IV. Procedures for the General Information Exchange

1. Participating States agree to exchange general information on risks associated with transfers of conventional arms and dual-use goods and technologies in order to consider, where necessary, the scope for co-ordinating national control policies to combat these risks.

2. In furtherance of this objective, and in keeping with the commitment to maximum restraint as a matter of national policy when considering applications for the export of arms and sensitive dual-use goods to all destinations where the risks are judged greatest, in particular to regions where conflict is occurring, Participating States also agree to exchange information on regions they consider relevant to the purposes of the Arrangement. These Regional Views should be based on, but not limited to, Section 2 of the "Elements for Objective Analysis and Advice Concerning Potentially Destabilising Accumulations of Conventional Weapons" (adopted by the 1998 Plenary).

3. A list of possible elements of the general information exchange on non-participating states is contained in Appendix 1.

V. Procedures for the Exchange of Information on Dual-Use Goods and Technology

1. Participating States will notify licences denied to non-participants with respect to items on the List of Dual-Use Goods and Technologies, where the reasons for denial are relevant to the purposes of the Arrangement.

2. For the Dual-Use List, Participating States will notify all licences denied relevant to the purposes of the Arrangement to non-participating states, on an aggregate basis, twice per year. The indicative content of these denial notifications is described in Appendix 2.

3. For items in the Sensitive List and Very Sensitive List, Participating States will notify, on an individual basis, all licences denied pursuant to the purposes of the Arrangement to non-participating states. Participating States agree that notification shall be made on an early and timely basis, that is, preferably within 30 days but no later than within 60 days, of the date of the denial. The indicative content of these denial notifications is described in Appendix 2.

4. For items in the Sensitive List and Very Sensitive List, Participating States will notify licences issued or

transfers made relevant to the purposes of the Arrangement to non-participants, on an aggregate basis, twice per year. The indicative content of these licence/transfer notifications is described in Appendix 2.

5. Participating States will exert extreme vigilance for items included in the Very Sensitive List by applying to those exports national conditions and criteria. They will discuss and compare national practices at a later stage.

6. Participating States agree that any information on specific transfers, in addition to that specified above, may be requested inter alia through normal diplomatic channels.

VI. Procedures for the Exchange of Information on Arms

1. Participating States agree that the information to be exchanged on arms will include any matters which individual Participating States wish to bring to the attention of others, such as emerging trends in weapons programmes and the accumulation of particular weapons systems, where they are of concern, for achieving the objectives of the Arrangement.

2. As an initial stage in the evolution of the new Arrangement, Participating States will exchange information every six months on deliveries to non-participating states of conventional arms set forth in Appendix 3, derived from the categories of the UN Register of Conventional Arms. The information should include the quantity and the name of the recipient state and, except in the category of missiles and missile launchers, details of model and type.

3. Participating States agree that any information on specific transfers, in addition to that specified above, may be requested inter alia through normal diplomatic channels.

VII. Meetings and Administration

1. Participating States will meet periodically to take decisions regarding this Arrangement, its purposes and its further elaboration, to review the lists of controlled items, to consider ways of co-ordinating efforts to promote the development of effective export control systems, and to discuss other relevant matters of mutual interest, including information to be made public.

2. Plenary meetings will be held at least once a year and chaired by a Participating State on the basis of annual rotation. Financial needs of the Arrangement will be covered under annual budgets, to be adopted by Plenary Meetings.

3. Working Groups may be established, if the Plenary meeting so decides.

4. There will be a secretariat with a staff necessary to undertake the tasks entrusted to it.

5. All decisions in the framework of this Arrangement will be reached by consensus of the Participating States.

VIII. Participation

The new Arrangement will be open, on a global and non-discriminatory basis, to prospective adherents that comply with the agreed criteria in Appendix 4. Admission of new participants will be based on consensus.

IX. Confidentiality

Information exchanged will remain confidential and be treated as privileged diplomatic communications. This confidentiality will extend to any use made of the information and any discussion among Participating States.

APPENDIX 1

GENERAL INFORMATION EXCHANGE

Indicative Contents

The following is a list of possible principal elements of the general information exchange on non-participating states, pursuant to the purposes of the agreement (not all elements necessarily applying to both arms and dual-use goods and technology):

1. Acquisition activities

- Companies/organisations
- Routes and methods of acquisition
- Acquisition networks inside/outside the country
- Use of foreign expertise
- Sensitive end-users
- Acquisition patterns
- Conclusions.

2. Export policy

- Export control policy
- Trade in critical goods and technology
- Conclusions.

3. Projects of Concern

- Description of the project
- Level of technology
- Present status of development
- Future plans
- Missing technology (development and production)

- Companies/organisations involved, including end-user(s)
- Diversion activities
- Conclusions.

4. Other matters

Specific Information Exchange on Dual-Use Goods and Technologies

Indicative Content of Notifications

The content of denial notifications for the Dual-Use List will be based on, but not be limited to, the following indicative or illustrative list:

- From (country)
- Country of destination
- Item number on the Control List
- Short description
- Number of licences denied
- Number of units (quantity)
- Reason for denial.

Denial notification for items in the Sensitive List and the Very Sensitive List will be on the basis of, but not be limited to, the following indicative or illustrative list:

- From (country)
- Item number on the Control List
- Short description
- Number of units (quantity)
- Consignee(s)
- Intermediate consignee(s) and/or agent(s):

  Name
  Address
  Country

- Ultimate consignee(s) and/or end-user(s):

  Name
  Address
  Country

  Stated end-use
  Reason for the denial
  Other relevant information.

The content of notifications for licences/transfers in the Sensitive List will be based on, but not be limited to, the following indicative or illustrative list:

- From (country)
- Item number on the Control List
- Short description
- Number of units (quantity)
- Destination (country).

APPENDIX 3[4]

SPECIFIC INFORMATION EXCHANGE ON ARMS

Content by Category

1. Battle Tanks

Tracked or wheeled self-propelled armoured fighting vehicles with high cross-country mobility and a high level of self-protection, weighing at least 16.5 metric tonnes unladen weight, with a high muzzle velocity direct fire main gun of at least 75 mm calibre.

2. Armoured Combat Vehicles

2.1 Tracked, semi-tracked or wheeled self-propelled vehicles, with armoured protection and cross-country capability designed, or modified and equipped:

2.1.1 to transport a squad of four or more infantrymen, or

2.1.2 with an integral or organic weapon of at least 12.5 mm calibre, or

2.1.3 with a missile launcher.

2.2 Tracked, semi-tracked or wheeled self-propelled vehicles, with armoured protection and cross-country capability specially designed, or modified and equipped:

2.2.1 with organic technical means for observation, reconnaissance, target indication, and designed to perform reconnaissance missions, or

2.2.2 with integral organic technical means for command of troops, or

2.2.3 with integral organic electronic and technical means designed for electronic warfare.

2.3 Armoured bridge-launching vehicles.

3. Large Calibre Artillery Systems

3.1 Guns, howitzers, mortars, and artillery pieces combining the characteristics of a gun or a howitzer capable of engaging surface targets by delivering primarily indirect fire, with a calibre of 75 mm to 155 mm, inclusive.

3.2 Guns, howitzers, mortars, and artillery pieces combining the characteristics of a gun or a howitzer capable of engaging surface targets by delivering primarily indirect fire, with a calibre above 155 mm.

3.3 Multiple-launch rocket systems capable of engaging surface targets, including armour, by delivering primarily indirect fire with the calibre of 75 mm and above.

3.4 Gun-carriers specifically designed for towing artillery.

4. Military Aircraft/Unmanned Aerial Vehicles

4.1 Military Aircraft:

Fixed-wing or variable-geometry wing aircraft which are designed, equipped or modified:

4.1.1 to engage targets by employing guided missiles, unguided rockets, bombs, guns, machine guns, cannons or other weapons of destruction.

4.1.2 to perform reconnaissance, command of troops, electronic warfare, electronic and fire suppression of air defence systems, refuelling or airdrop missions.

4.2 Unmanned Aerial Vehicles:

Unmanned aerial vehicles, specially designed, modified, or equipped for military use including electronic warfare, suppression of air defence systems, or reconnaissance missions, as well as systems for the control and receiving of information from the unmanned aerial vehicles.

"Military Aircraft" does not include primary trainer aircraft, unless designed, equipped or modified as described above.

5. Military and Attack Helicopters

Rotary-wing aircraft which are designed, equipped or modified to:

5.1 engage targets by employing guided or unguided, air-to-surface, anti-armour weapons, air to sub-surface or air-to-air weapons, and equipped with an integrated fire-control and aiming system for these weapons.

5.2 perform reconnaissance, target acquisition (including anti-submarine warfare), communications, command of troops, or electronic warfare, or mine laying missions.

6. Warships[5]

Vessel or submarines armed and equipped for military use with a standard displacement of 150 metric tonnes or above, and those with a standard displacement of less than 150 metric tonnes equipped for launching missiles with a range of at least 25 km or torpedoes with a similar range.

7. Missiles or Missile Systems

Guided or unguided rockets, ballistic or cruise missiles capable of delivering a warhead or weapon of destruction to a range of at least 25 km, and means designed or modified specifically for launching such missiles or rockets, if not covered by categories 1 to 6.

This category:

7.1 also includes remotely piloted vehicles with the characteristics for missiles as defined above;

7.2 does not include ground-to-air missiles.

8. Small Arms and Light Weapons—Man-Portable Weapons made or modified to military specification for use as lethal instruments of war

8.1 Small Arms—broadly categorised for reporting purposes as: those weapons intended for use by individual members of armed forces or security forces, including revolvers and self-loading pistols; rifles and carbines; submachine guns; assault rifles; and light machine guns.

8.2 Light Weapons—broadly categorised for reporting purposes as: those weapons intended for use by individual or several members of armed or security forces serving as a crew and delivering primarily direct fire. They include heavy machine guns; hand-held under-barrel and mounted grenade launchers; portable anti-tank guns; recoilless rifles; portable launchers of anti-tank missile and rocket systems; and mortars of calibre less than 75 mm.

8.3 Man-Portable Air-Defence Systems—broadly categorised for reporting purposes as: surface-to-air missile systems intended for use by an individual or several members of armed forces serving as a crew.

Participation Criteria

When deciding on the eligibility of a state for participation, the following factors, inter alia, will be taken into consideration, as an index of its ability to contribute to the purposes of the new Arrangement:

Whether it is a producer/exporter of arms or industrial equipment respectively;

Whether it has taken the WA Control lists as a reference in its national export controls;

Its non-proliferation policies and appropriate national policies, including:

Adherence to non-proliferation policies, control lists and, where applicable, guidelines of the Nuclear Suppliers Group, the Zangger Committee, the Missile Technology Control Regime and the Australia Group; and through adherence to the Nuclear Non-Proliferation Treaty, the Biological and Toxicological Weapons Convention, the Chemical Weapons Convention and (where applicable) START I, including the Lisbon Protocol;

Its adherence to fully effective export controls.

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